SMOKY HILL-SALINE BASIN TOTAL MAXIMUM DAILY LOAD

Waterbody / Assessment Unit: Mulberry Creek and Saline River
Water Quality Impairment: Total Phosphorus

1. INTRODUCTION AND PROBLEM IDENTIFICATION

Subbasin: Lower Saline River **Counties** Ottawa, Lincoln, Ellsworth, and Saline

HUC 8: **10260010**
HUC10 (HUC12**)**: **03** (06, 07)
04 (01, 02, 03, 04, 05, 06, 07)
05 (01, 02, 03, 04, 05)

Ecoregion: Smoky Hills (27a)

Drainage Area: Approximately 563.9 square miles

Main Stem Water Quality Limited Segments:

Water Quality Limited Segments Covered Under this TMDL *(designated uses for main stem and tributary segments are detailed in **Table 1**)*:

Station	***Main Stem Segment***	***Tributaries***	
SC640	Mulberry Cr (19)	Dry Cr (29)	
	Mulberry Cr (20)	Spring Cr (24)	Spring Cr, West (25)
			Spring Cr (26)
			Spring Cr (27)
			Ralston Cr (28)
	Mulberry Cr (21)	Eff Cr (23)	
	Mulberry Cr (22)	Table Rock Cr (40)	
SC267	Saline R (1)	Mulberry Cr (19)	
	Saline R (2)	Shaw Cr (41)	
	Saline R (3)	Owl Cr (39)	
		Table Rock Cr (18)	

303(d) Listings: Kansas Stream segments monitored by station SC267 **(Figure 1)**, Saline River near New Cambria, are cited as impaired by Total Phosphorus (TP) in 2008, 2010, 2012, 2014, 2016 & 2018 for the Smoky Hill-Saline Basin.

Kansas Stream segments monitored by station SB267, Saline River near New Cambria, are cited as impaired by Biology (Bio) in 2012, 2014, 2016 & 2018 for the Smoky Hill-Saline Basin.

Kansas Stream segments monitored by station SC640, Mulberry Creek near Salina, are cited as impaired by TP in 2008, 2010, 2012, 2014, 2016 & 2018 for the Smoky Hill-Saline Basin.

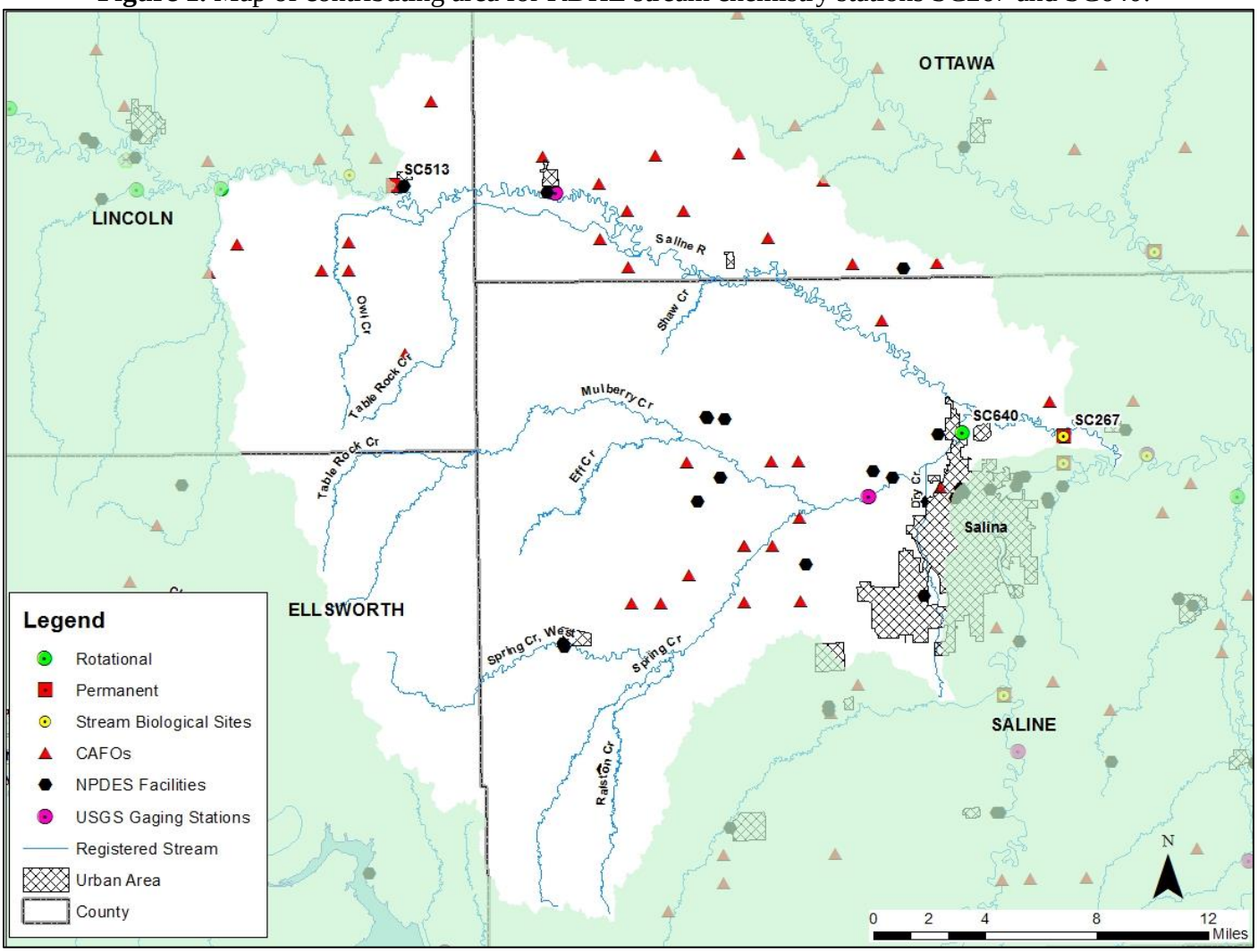
Table 1. Designated uses for main stem and tributary segments in the watershed (Kansas Department of Health and Environment, 2013).

Stream	Segment #	Expected Aquatic Life	Contact Recreation	Domestic Supply	Food Procurement	Ground Water Recharge	Industrial Water Use	Irrigation Use	Livestock Watering Use
HUC8: 10260010									
Mulberry Cr	**19**	**E**	**b**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Dry Cr	29	E	a	Y	Y	Y	Y	Y	Y
Mulberry Cr	**20**	**E**	**b**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Spring Cr	24	E	b	Y	N	Y	Y	Y	Y
Spring Cr, West	25	E	b	Y	N	Y	Y	Y	Y
Spring Cr	26	E	b	N	N	Y	N	Y	Y
Spring Cr	27	E	b	N	N	Y	N	Y	Y
Ralston Cr	28	E	b	N	N	Y	N	Y	Y
Mulberry Cr	**21**	**E**	**b**	**Y**	**N**	**Y**	**Y**	**Y**	**Y**
Eff Cr	23	E	b	N	Y	Y	N	Y	Y
Mulberry Cr	**22**	**E**	**C**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Table Rock Cr	40	E	b	N	N	Y	N	Y	Y
Saline R	**1**	**E**	**C**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Saline R	**2**	**E**	**C**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Shaw Cr	41	E	b	Y	Y	Y	Y	Y	Y
Saline R	**3**	**E**	**b**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**
Owl Cr	39	E	b	N	N	Y	N	Y	Y
Table Rock Cr	18	E	b	N	N	Y	N	Y	Y

Y=use is designated; N=use is not designated; E=Expected aquatic life; A, B, C=Primary Contact Recreation; a, b=Secondary Contact Recreation

Impaired Use: Expected Aquatic Life, Contact Recreation, Domestic Water Supply.

Figure 1. Map of contributing area for KDHE stream chemistry stations SC267 and SC640.



Water Quality Criteria:

***Nutrients -- Narrative*:**
The introduction of plant nutrients into streams, lakes, or wetlands from artificial sources shall be controlled to prevent the accelerated succession or replacement of aquatic biota or the production of undesirable quantities or kinds of aquatic life (K.A.R. 28-16-28e(d)(2)(A)).

The introduction of plant nutrients into surface waters designated for primary or secondary contact recreational use shall be controlled to prevent the development of objectionable concentrations of algae or algal by-products or nuisance growths of submersed, floating, or emergent aquatic vegetation (K.A.R. 28-16-28e(d) (7)(A)).

The introduction of plant nutrient into surface waters designated for domestic water supply use shall be controlled to prevent interference with the production of drinking water (K.A.R. 28-16-28e(d)(3)(D)).

Taste-producing and odor-producing substances of artificial origin shall not occur in surface waters at concentrations that interfere with the production of potable water by conventional water treatment processes, that impart an unpalatable flavor to edible aquatic or semiaquatic life or terrestrial wildlife, or that result in noticeable odors in the vicinity of surface waters (K.A.R. 28-16-28e(b)(7)).

Dissolved Oxygen -- Numeric:
The concentration of dissolved oxygen in surface waters shall not be lowered by the influence of artificial sources of pollution. The Dissolved Oxygen criterion is 5 mg/L (K.A.R. 28-16-28e(e)).

pH – Numeric: Artificial sources of pollution shall not cause the pH of any surface water outside of a zone of initial dilution to be below 6.5 and above 8.5 (K.A.R. 28-16-28e(e)): Tables of Numeric Criteria).

2. CURRENT WATER QUALITY CONDITIONS AND DESIRED ENDPOINT

Level of Support for Designated Uses under the 2018 303(d) List: Phosphorus levels in Saline River near New Cambria (SC267) and Mulberry Creek near Salina (SC640) are consistently high. Excessive nutrients are not being controlled and are thus impairing aquatic life, domestic water supply, and contact recreation uses. The ultimate endpoint of this Total Maximum Daily Load (TMDL) will be to achieve the Kansas Surface Water Quality Standards by eliminating excessive primary productivity and impairment to aquatic life, recreation, and domestic water supply associated with excessive phosphorus.

Station Location and Period of Record

Stream Chemistry (SC) Monitoring Station

SC267: Active, permanent station on the Saline River near New Cambria, located on County Road Bridge, 2.0 miles West and 0.25 miles North of New Cambria. Period of record: March 14, 1990 to April 9, 2018.

SC513: Active, permeant station on the Saline River near Beverly, located on County Road Bridge, 0.75 miles Southwest of Beverly. Period of record: March 20, 1990 to May 21, 2018.

SC640: Active, rotational station on Mulberry Creek near Salina, located on I-70 Highway Bridge, 0.5 miles East of Junction K-143 and I-70 Highways. Period of record: February 26, 1991 to December 5, 2017.

Stream Biology (SB) Monitoring Stations

SB267: Active station on Saline River near New Cambria located on County Road Bridge, 2.0 miles West and 0.25 miles North of New Cambria. Period of record: September 26, 1990 to June 8, 2016.

Streamflow Gage

U.S. Geological Survey 06869500: Saline River at Tescott. Period of record: January 1, 1990 to December 31, 2017. Located on the Saline River (SC267).

U.S. Geological Survey 06869950: Mulberry Creek near Salina. Period of record: March 1, 2002 to December 31, 2017. Located on Mulberry Creek (SC640).

Hydrology:

Streamflow conditions at SC640 were analyzed using USGS streamgage data from Mulberry Creek near Salina (06869950). This USGS gage is located near KDHE station Mulberry Creek near Salina (SC640) and has streamflow data available for the period of record March 1, 2002 to December 31, 2017. Flow conditions from January 1, 1990 to February 28, 2002 were based on a regression analysis between the 95 percent exceedance and 5 percent exceedance for Mulberry USGS gage (06869950) and Saline USGS gage (06869500). A watershed ratio between this analysis or USGS gage 06869950 and the location of the SC site was used to estimate streamflow in Mulberry Creek at SC640 (**Table 2**). **Figure 2** displays the flow duration curve.

Streamflow conditions at SC267 analyzed using U.S. Geological Survey (USGS) streamgage data from Saline River at Tescott (06869500). This USGS gage is located near Kansas Department of Health and Environment (KDHE) stream chemistry (SC) station Saline River near New Cambria (SC267) and has streamflow data available for the period of record January 1, 1990 to December 31, 2017. A watershed ratio between the USGS gage and the location of the SC site was used to estimate streamflow in the Saline River at SC267 (**Table 2**). **Figure 3** displays the flow duration curve.

Table 2. Kansas Department of Health and Environment (KDHE) estimated flow conditions at stream chemistry (SC) stations on the Saline River near New Cambria (SC267), Mulberry Creek near Salina (SC640), and the Saline River near Beverly (SC513) and monitored flow conditions at U.S. Geological Survey (USGS) gages.

Stream	Station	Contributing Drainage Area (mi^2)	Mean Flow (CFS)	Percent Flow Exceedance (CFS)				
				90%	75%	50%	25%	10%
Saline River	KDHE SC267	3019	228.3	16.06	23.23	50.32	153.60	516.40
Saline River	USGS 06869500	2820	213.3	15.00	21.70	47.00	143.50	482.40
Saline River	KDHE SC513	2770	203.0	14.20	22.80	42.80	118.00	467.00
Mulberry Creek	KDHE SC640	316	63.6	0.19	2.61	7.69	26.80	102.30
Mulberry Creek	USGS 06869950	261	52.6	0.16	2.16	6.35	22.1	84.5

Table 3. U.S. Geological Survey (USGS) long term estimated flows for the Saline River, Mulberry Creek, and their tributaries (Perry et.al, 2004).

Stream	KSWR CUSEGA Number	County	Drainage Area (mi^2)	Mean Flow (CFS)	Percent Flow Exceedance (CFS)					2-year Peak (CFS)
					90%	75%	50%	25%	10%	
Owl Creek	1026001039	LC	33.70	7.35	0.00	0.24	1.46	3.34	8.13	909.00
Table Rock Cr	1026001018	LC; OT	44.10	11.70	0.00	0.75	2.78	6.51	15.10	997.00
Saline River	**102600103**	**LC; OT**	**2,840.00**	**212.00**	**15.00**	**24.00**	**45.00**	**126.00**	**490.00**	**2,530.00**
Shaw Cr	102600102	SA	13.60	3.74	0.00	0.01	0.82	1.63	3.98	739.00
Saline River	**1026001041**	**SA**	**2,980.00**	**219.00**	**15.80**	**25.40**	**47.70**	**132.00**	**510.00**	**2,580.00**
Table Rock Cr	1026001040	EW; LC	22.80	5.74	0.00	0.24	1.37	2.90	6.62	940.00
Mulberry Cr	**1026001022**	**EW; LC**	**26.30**	**7.29**	**0.00**	**0.53**	**2.06**	**4.36**	**9.42**	**1,020.00**
Eff Creek	1026001023	SA	35.00	10.10	0.00	0.71	2.69	6.09	13.60	921.00
Mulberry Cr	**1026001021**	**SA**	**137.00**	**36.30**	**0.00**	**3.10**	**9.51**	**23.20**	**54.50**	**1,910.00**
Spring Cr, West	1026001025	EW; SA	51.70	14.50	0.00	1.20	4.02	9.25	20.50	1,160.00
Spring Cr	1026001027	SA	**25.90**	**6.71**	**0.00**	**0.33**	**1.70**	**3.69**	**8.25**	**994.00**
Ralston Cr	1026001028	SA	29.20	8.33	0.00	0.56	2.27	4.99	11.00	1,100.00
Spring Cr	1026001024	SA	**140.00**	**37.20**	**0.00**	**3.19**	**9.86**	**24.10**	**56.40**	**1,820.00**
Mulberry Cr	**1026001020**	**SA**	**292.00**	**74.70**	**1.14**	**6.65**	**20.20**	**49.70**	**120.00**	**2,310.00**
Dry Cr	1026001029	SA	24.30	6.22	0.00	0.00	0.77	2.05	6.01	1,150.00
Mulberry Cr	**1026001019**	**SA**	**321.00**	**82.10**	**1.38**	**7.22**	**21.90**	**54.00**	**132.00**	**2,500.00**
Saline River	**102600101**	**SA**	**3,320.00**	**237.00**	**17.90**	**28.90**	**54.40**	**149.00**	**562.00**	**2,720.00**

Figure 2. Estimated flow duration curve for Kansas Department of Health and Environment station Mulberry Creek near Salina (SC640) based upon U.S. Geological Survey gaged site located in Mulberry Creek near Salina (06869950).

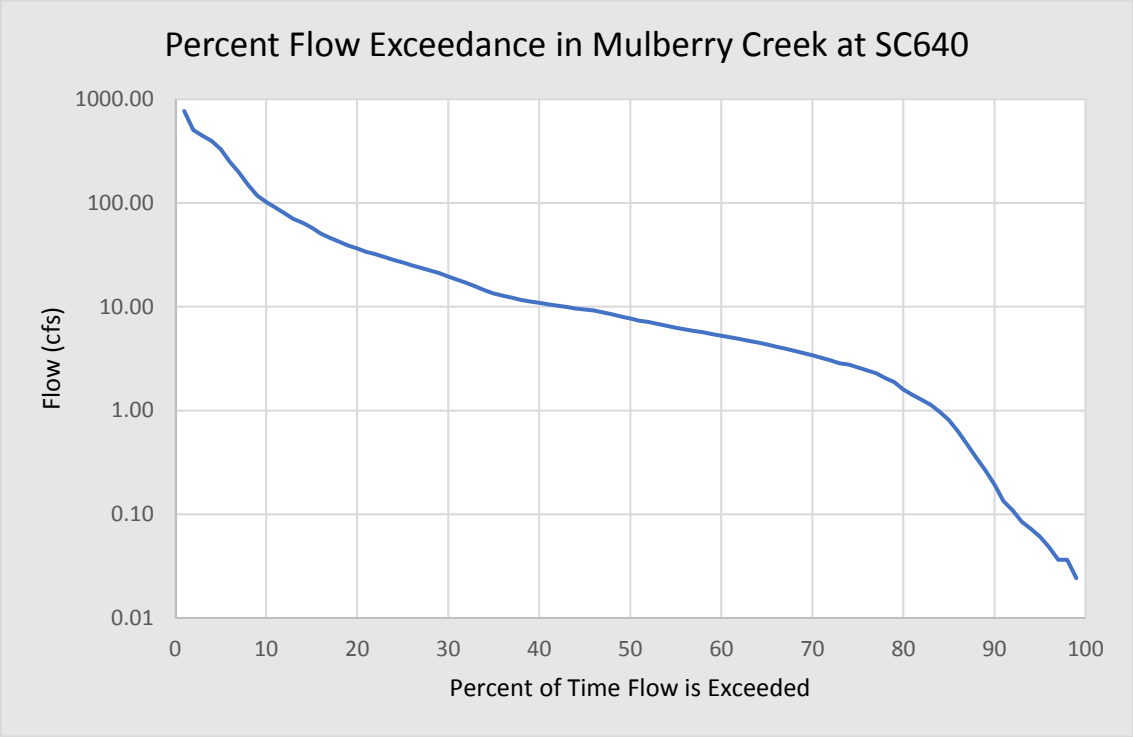
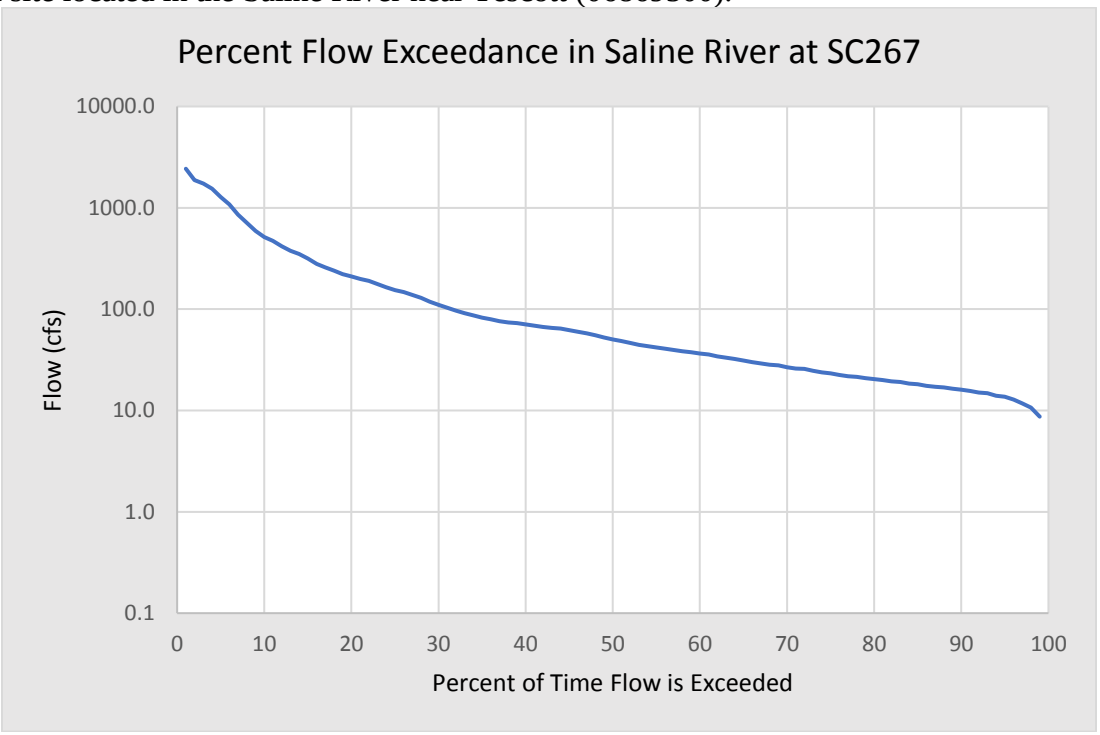


Figure 3. Estimated flow duration curve for Kansas Department of Health and Environment station on the Saline River near New Cambria (SC267) based upon U.S. Geological Survey gaged site located in the Saline River near Tescott (06869500).



The highest mean annual flows in Mulberry Creek near Salina (SC640) occurred in 1993 and 2007, with flows of 552.0 and 197.5 cubic feet per second (cfs), respectively (**Figure 4**). The highest median annual flows occurred in 1993 and 1998 with flows of 436.6 and 38.0 cfs, respectively. The lowest mean annual flows occurred in 2002 and 2005 with flows of 6.9 and 6.4 cfs, respectively. The lowest median annual flows occurred in 2005, 2006 and 2007 at 0.4 cfs. The highest mean annual flows in the Saline River near New Cambria (SC267) occurred in 1993 and 1995, with flows of 1,772.2 and 570.4 cfs, respectively (**Figure 5)**. The highest median annual flows occurred in 1993 and 1998 with flows of 1,7450.0 and 220.5 cfs, respectively. The lowest mean annual flows occurred in 2006 and 2015 with flows of 14.4 and 31.5 cfs, respectively. The lowest median annual flows occurred in 2006, 2014, and 2015 with flows ranging from 14.0-18.7 cfs

The peak annual flows for Mulberry Creek occurred in 1993 and 2007 with flows of 5,094.6 and 18,645.2 cfs, respectively (**Figure 6**). The peak annual flows for the Saline River occurred in 1993 and 1995 with flows of 8,800.1 and 7,022.9 cfs, respectively (**Figure 7**). Seasonally, high flows occur in spring (April through June) and low flows occur in summer-fall (July through October) and winter (November through March). Spring flows are skewed by high flow events, likely due to precipitation and runoff events, and coincide with higher mean flows in May (**Figure 8**). Spring flows are skewed by high flow events, likely due to precipitation and runoff events, and coincide with higher mean flows in May (**Figure 9**). The mean during the summer-fall season is higher than the winter season, indicating isolated, seasonal runoff events are likely occurring in the watershed. (**Figure 10 and Figure 11**).

Figure 4. Estimated annual mean and median flows for Mulberry Creek near Salina (SC640) based upon U.S. Geological Survey gaged site located in Mulberry Creek near Salina (06869950) and annual total precipitation at National Oceanic and Atmospheric Administration station in Brookville (USC00141057).

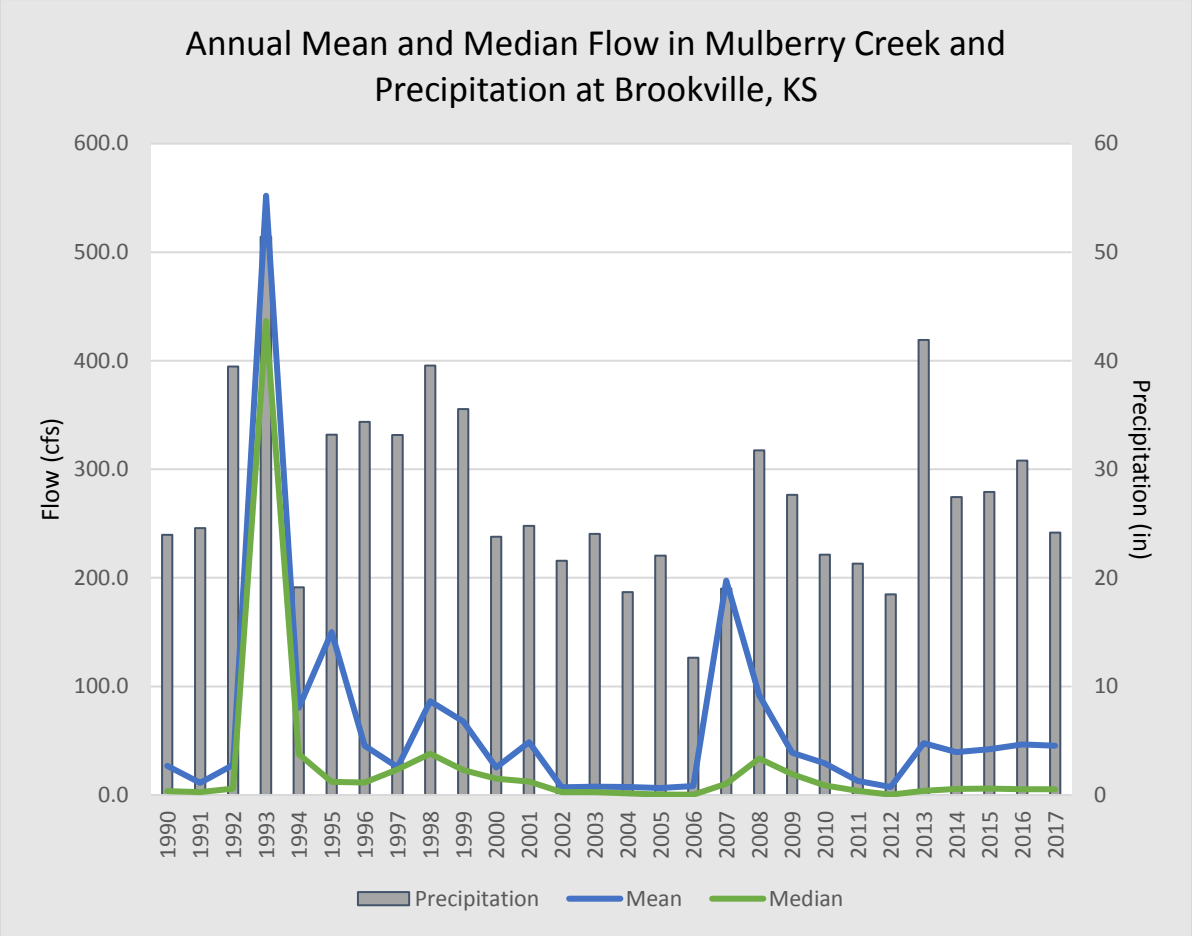


Figure 5. Estimated annual mean and median flows for the Saline River near New Cambria (SC267) based upon U.S. Geological Survey gaged site located in the Saline River near Tescott (06869500) and annual total precipitation at National Oceanic and Atmospheric Administration station in Lincoln (USC00144712).

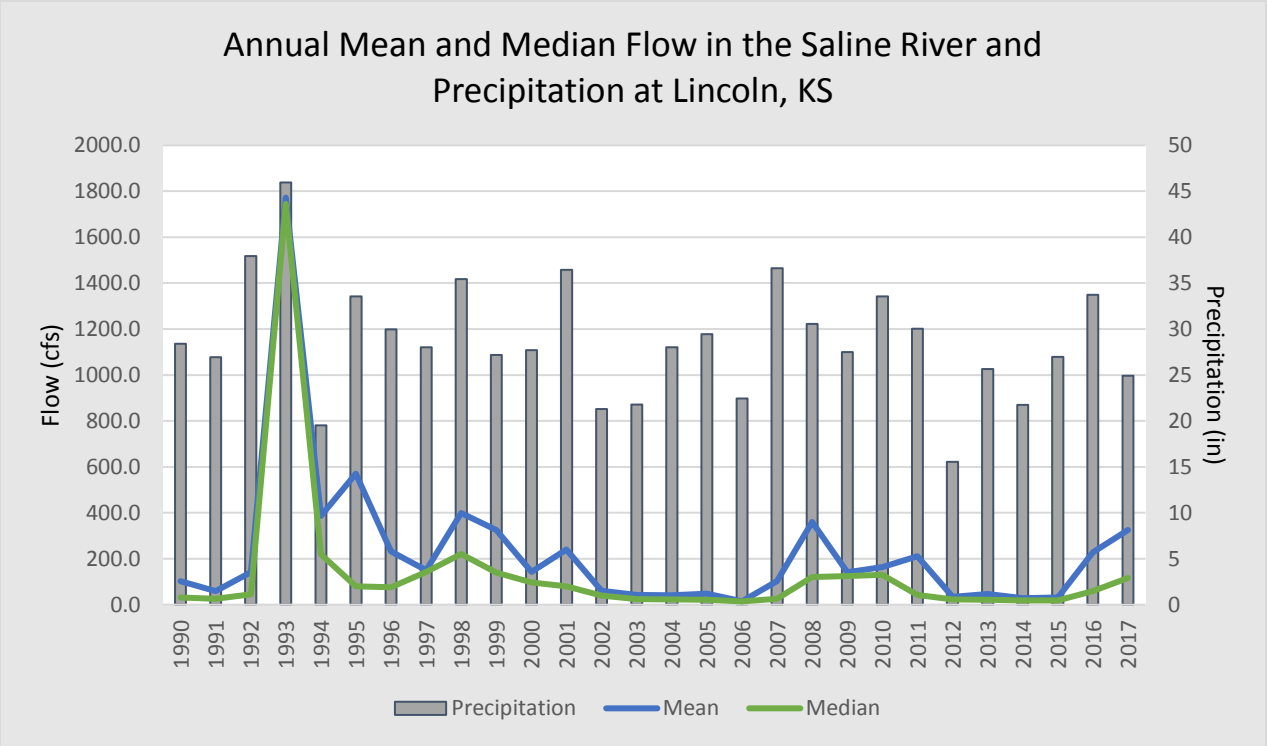


Figure 6. Estimated annual peak flows for Mulberry Creek near Salina (SC640). Only years with USGS Mulberry gage flow data are displayed.

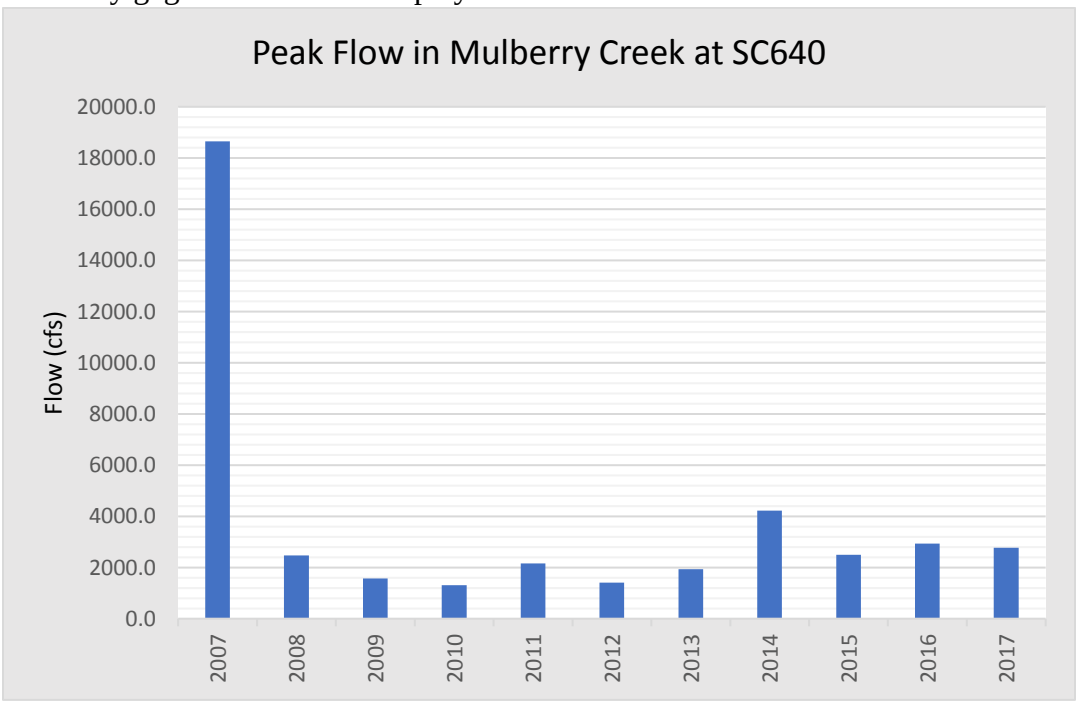


Figure 7. Estimated annual peak flows for the Saline River near New Cambria (SC267).

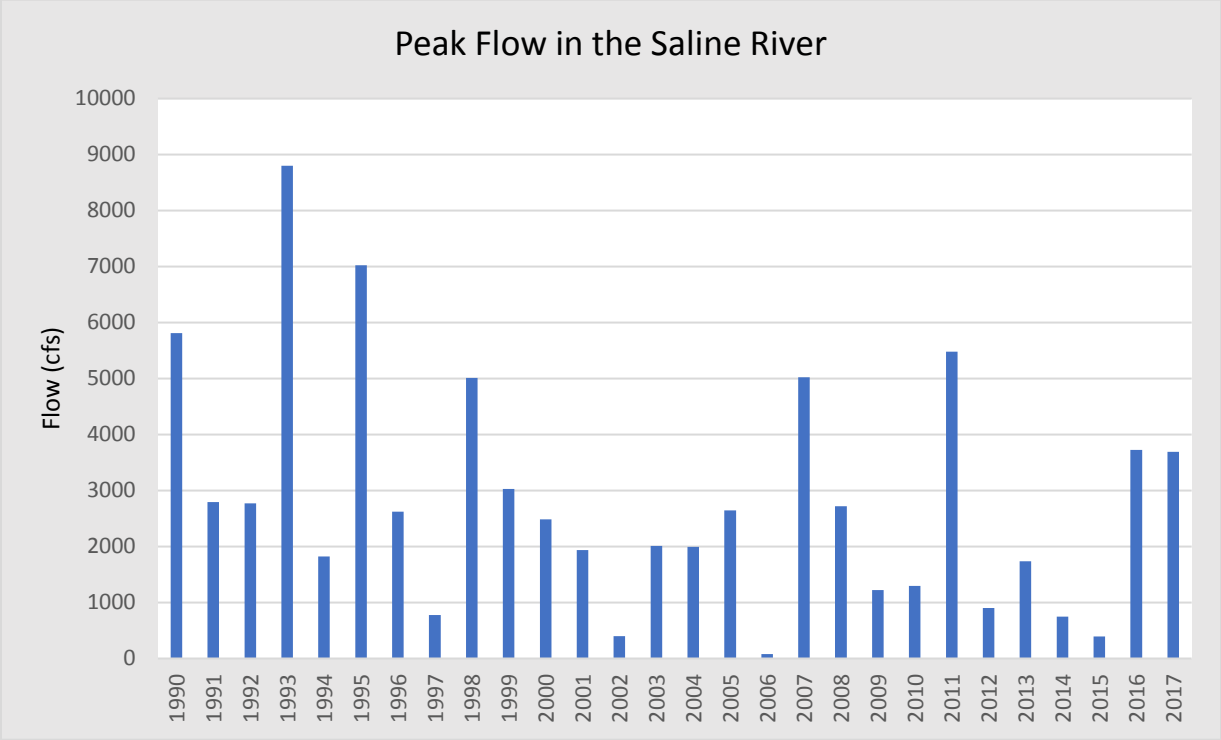


Figure 8. Estimated monthly mean and median flows for Mulberry Creek near Salina (SC640) from 1/1/1990-12/31/2017.

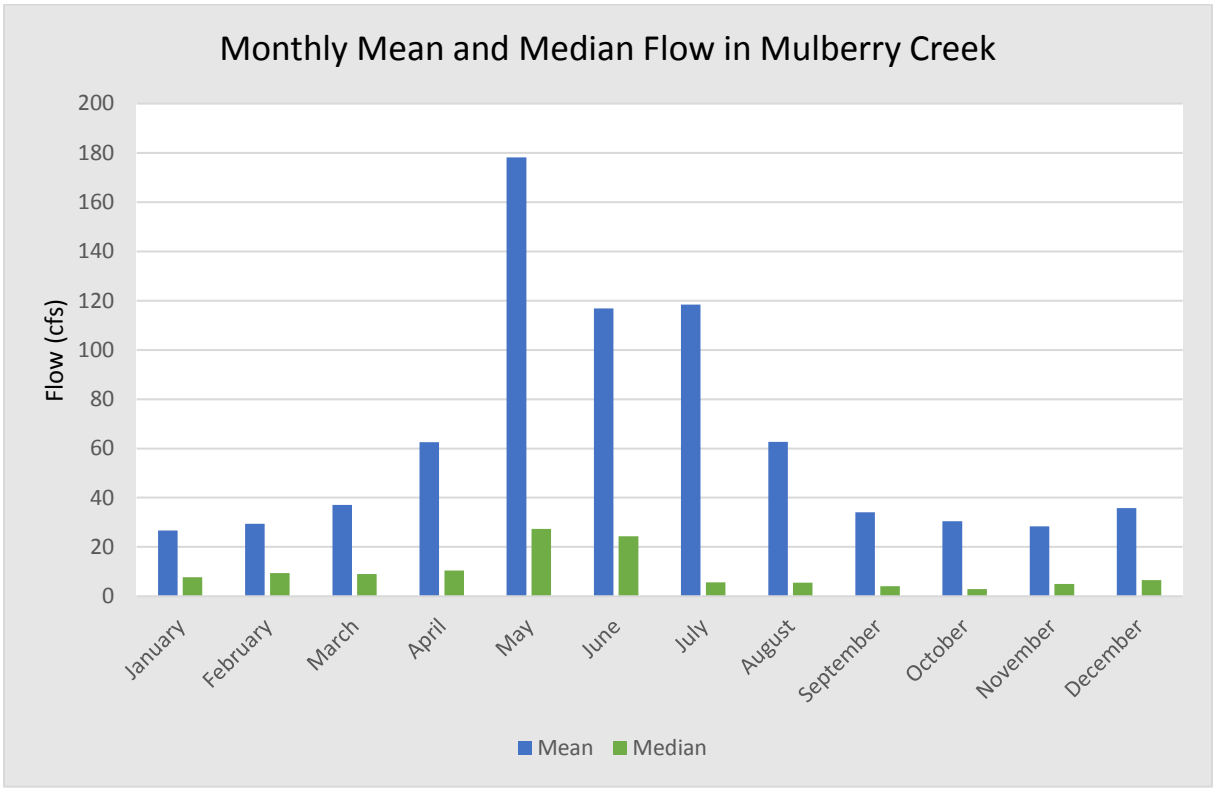


Figure 9. Estimated monthly mean and median flows for the Saline River near New Cambria (SC267) from 1/1/1990-12/31/2017.

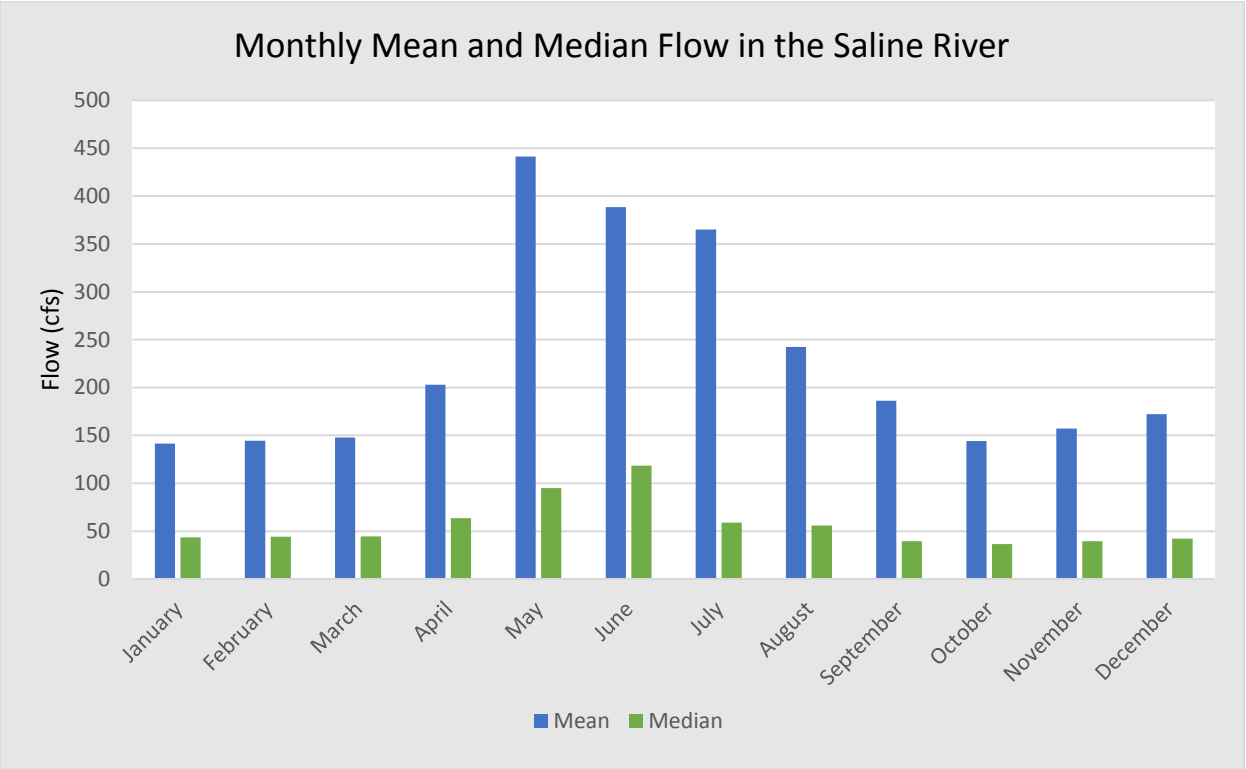


Figure 10. Estimated flows by season for Mulberry Creek near Salina (SC640) from 1/1/1990-12/31/2017.

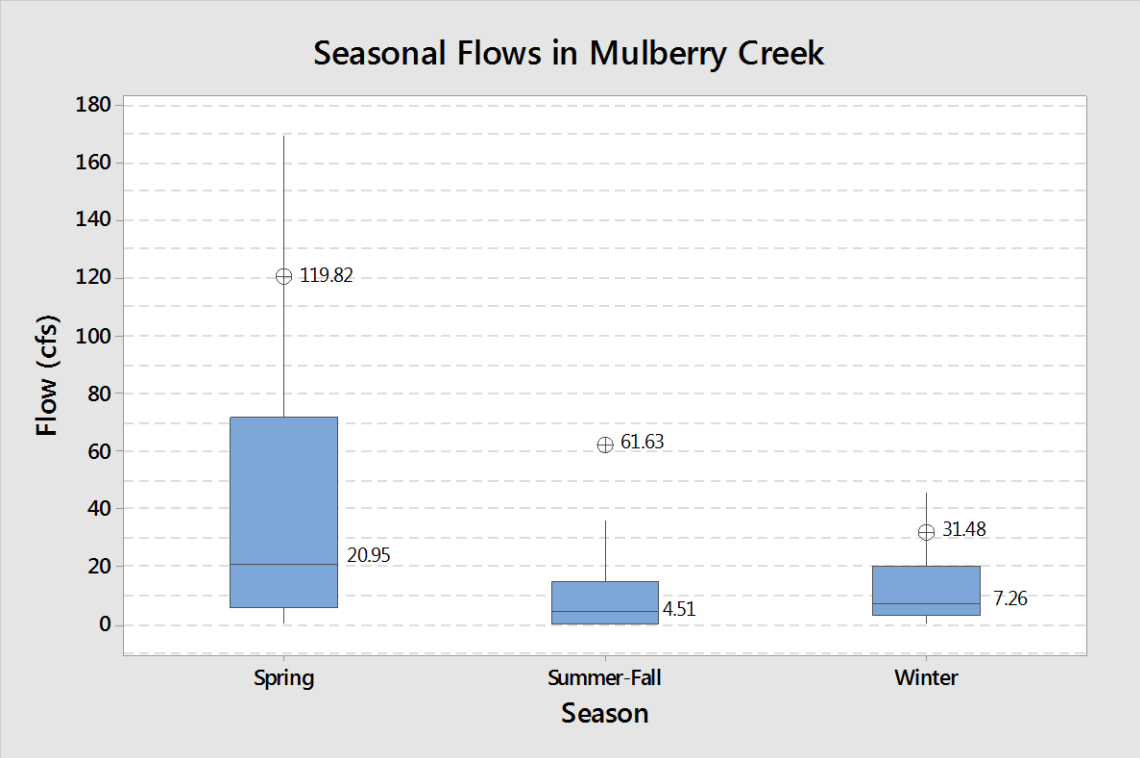
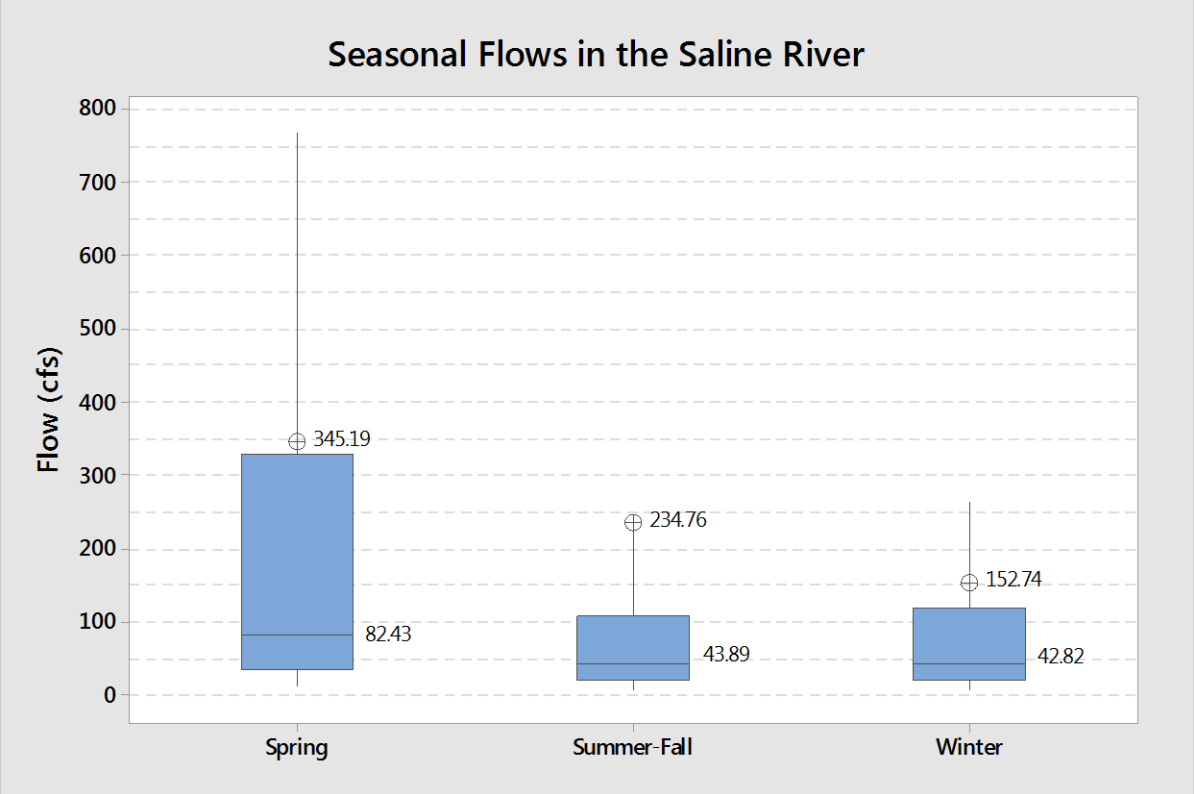


Figure 11. Estimated flows by season for the Saline River near New Cambria (SC267) from 1/1/1990-12/31/2017.



Total Phosphorus Concentrations

Mulberry Creek near Salina (SC640) is an active, rotational KDHE SC station with samples collected every four years since 1991, with one two-year sample period (**Table 4; Figure 12)**. The maximum annual total phosphorus (TP) concentration of 2.18 milligrams per liter (mg/L) occurred in 1991. From 1991 to 2017, Mulberry Creek near Salina (SC640) has a mean TP concentration of 0.371 mg/L and a median TP concentration of 0.201 mg/L. The highest annual TP concentration mean of 1.08 mg/L and median of 1.12 mg/L occurred in 1991. The lowest annual TP concentration mean of 0.175 mg/L and median of 0.175 mg/L occurred in 2017.

Saline River near New Cambria (SC267) is an active, permanent KDHE SC station with samples collected every year since 1990 (**Table 5; Figure 13**). The maximum annual TP concentration of 1.40 mg/L occurred in 1992. From 1990 to 2018, the Saline River near New Cambria (SC267) has a mean TP concentration of 0.293 mg/L and a median TP concentration of 0.215 mg/L. The highest annual TP concentration mean of 0.486 mg/L occurred in 2007 and the highest median of 0.470 mg/L occurred in 2016. The lowest annual TP concentration mean of 0.095 mg/L and median of 0.094 mg/L occurred in 2018, however this year there were only 2 samples.

The Saline River near Beverly (SC513) is an active, permanent KDHE SC station with samples collected every year since 1990. This station is upstream from the Saline River near New

Cambria (SC267). This SC station is not impaired for TP, but is upstream from SC267 on the Saline River near New Cambria and shown for comparison purposes. From 1990 to 2018, this site shows a mean TP concentration of 0.206 mg/L and a median TP concentration of 0.165mg/L indicating significant loading is occurring in the Saline River watershed between Beverly and New Cambria (**Table 5; Figure 14**). TP concentrations for Mulberry Creek and the Saline River by flow condition are displayed in **Figure 15 and Figure 16**. In watersheds influenced by nonpoint source loading, TP concentrations generally increase with increased flow as can be seen in the Saline River. In Mulberry Creek however, the TP to flow relationship is somewhat noisy, most likely because flows for samples taken in Mulberry Creek prior to March 2002 were estimated using regression analysis.

Table 4. Total phosphorus concentration annual mean, median, minimum, maximum, and sample number (N) for Mulberry Creek near Salina (SC640).

Year	Total Phosphorus (mg/L)			
	Mean	Median	Maximum	N
1991	1.08	1.12	2.18	6
1995	0.198	0.201	0.377	6
1999	0.183	0.190	0.260	6
2003	0.201	0.200	0.344	4
2007	0.387	0.253	1.01	6
2009	0.220	0.164	0.644	6
2013	0.526	0.209	1.57	4
2017	0.175	0.175	0.220	4
1991-2017	**0.371**	**0.201**	**2.18**	**42**
1991-1999	**0.486**	**0.201**	**2.18**	**18**
2000-2018	**0.302**	**0.200**	**1.57**	**24**

Table 5. Total phosphorus concentration annual mean, median, minimum, maximum, and sample number (N) for the Saline River near New Cambria (SC267) and the Saline River near Beverly (SC513).

Year	SC267 Total Phosphorus (mg/L)				SC513 Total Phosphorus (mg/L)			
	Mean	Median	Maximum	N	Mean	Median	Maximum	N
1990	0.270	0.290	0.310	5	0.254	0.260	0.410	5
1991	0.236	0.260	0.330	5	0.171	0.160	0.400	7
1992	0.430	0.255	1.40	6	0.257	0.210	0.600	6
1993	0.397	0.415	0.570	6	0.244	0.300	0.370	5
1994	0.358	0.240	0.990	6	0.277	0.170	0.960	6
1995	0.223	0.179	0.500	6	0.156	0.154	0.270	6
1996	0.394	0.201	1.26	5	0.283	0.126	0.634	5
1997	0.432	0.357	1.14	6	0.308	0.202	0.816	6
1998	0.426	0.340	0.930	7	0.244	0.228	0.520	6
1999	0.447	0.345	1.06	6	0.419	0.400	1.080	7
2000	0.175	0.130	0.340	6	0.172	0.120	0.360	6
2001	0.320	0.172	0.994	6	0.196	0.201	0.440	6
2002	0.226	0.146	0.617	6	0.169	0.111	0.378	6

Year	SC267 Total Phosphorus (mg/L)				SC513 Total Phosphorus (mg/L)			
	Mean	Median	Maximum	N	Mean	Median	Maximum	N
2003	0.172	0.194	0.266	5	0.148	0.165	0.235	5
2004	0.207	0.178	0.279	5	0.179	0.187	0.253	5
2005	0.337	0.329	0.724	6	0.103	0.098	0.165	6
2006	0.306	0.315	0.776	5	0.138	0.142	0.264	6
2007	0.486	0.444	1.11	6	0.158	0.152	0.243	5
2008	0.360	0.246	1.21	6	0.348	0.241	0.896	6
2009	0.280	0.127	0.882	5	0.131	0.122	0.225	4
2010	0.267	0.215	0.537	4	0.150	0.176	0.202	4
2011	0.232	0.126	0.635	4	0.137	0.109	0.305	4
2012	0.237	0.186	0.538	4	0.132	0.102	0.294	4
2013	0.266	0.384	0.419	5	0.123	0.068	0.285	5
2014	0.165	0.106	0.420	4	0.168	0.110	0.400	4
2015	0.201	0.215	0.330	4	0.167	0.190	0.260	4
2016	0.393	0.470	0.600	5	0.270	0.230	0.600	4
2017	0.164	0.112	0.370	4	0.137	0.136	0.220	4
2018	0.094	0.094	0.130	2	0.326	0.170	0.930	4
1990-2018	**0.293**	**0.215**	**1.40**	**150**	**0.206**	**0.165**	**1.080**	**151**
1990-1999	**0.361**	**0.275**	**1.40**	**58**	**0.261**	**0.206**	**1.080**	**59**
2000-2018	**0.257**	**0.186**	**1.21**	**92**	**0.176**	**0.147**	**0.930**	**92**

Figure 12. Total phosphorus by sampling date for Mulberry Creek near Salina (SC640).

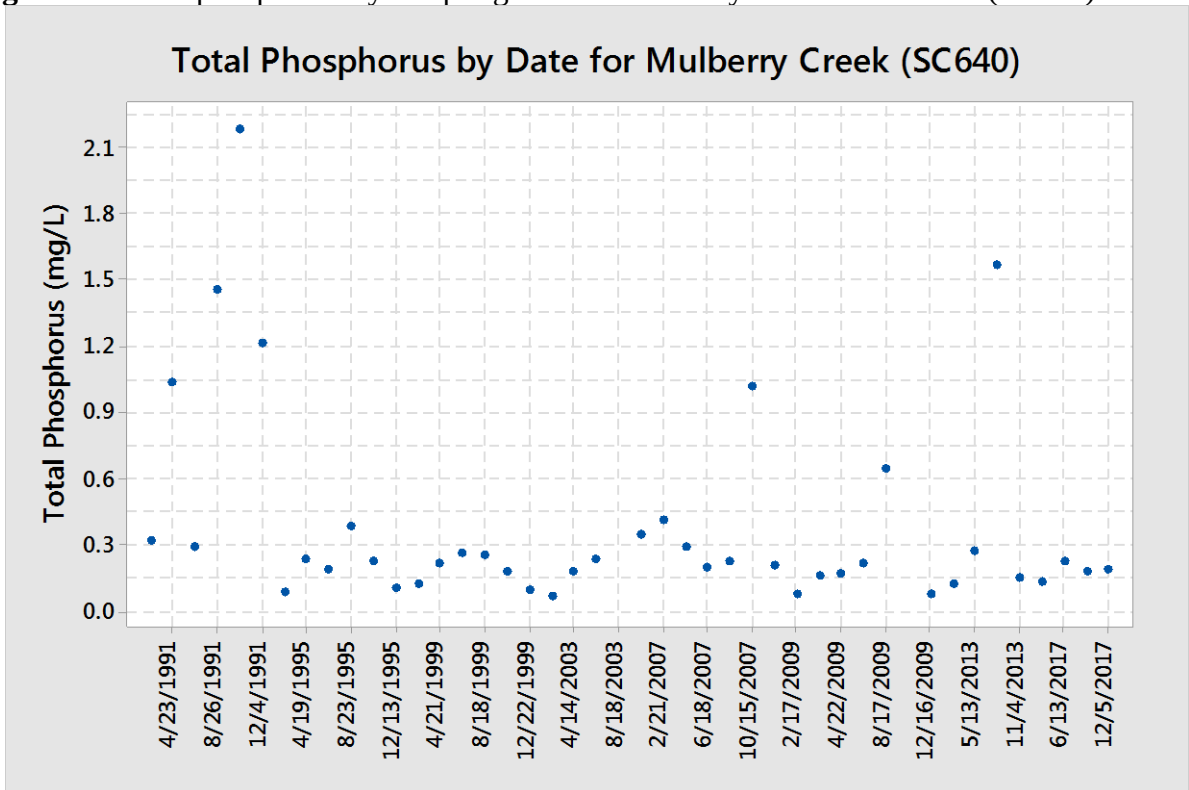


Figure 13. Total phosphorus by sampling date for the Saline River near New Cambria (SC267).

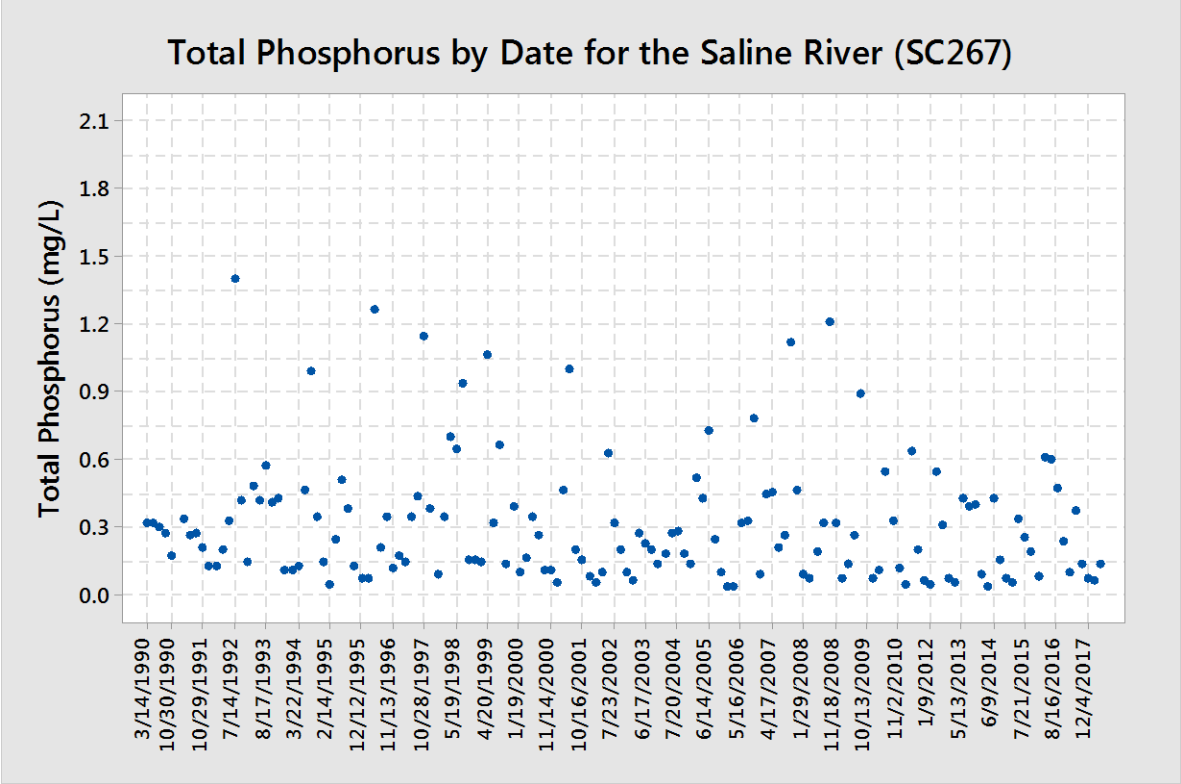


Figure 14. Total phosphorus for Mulberry Creek (SC640) and the Saline River (SC267).

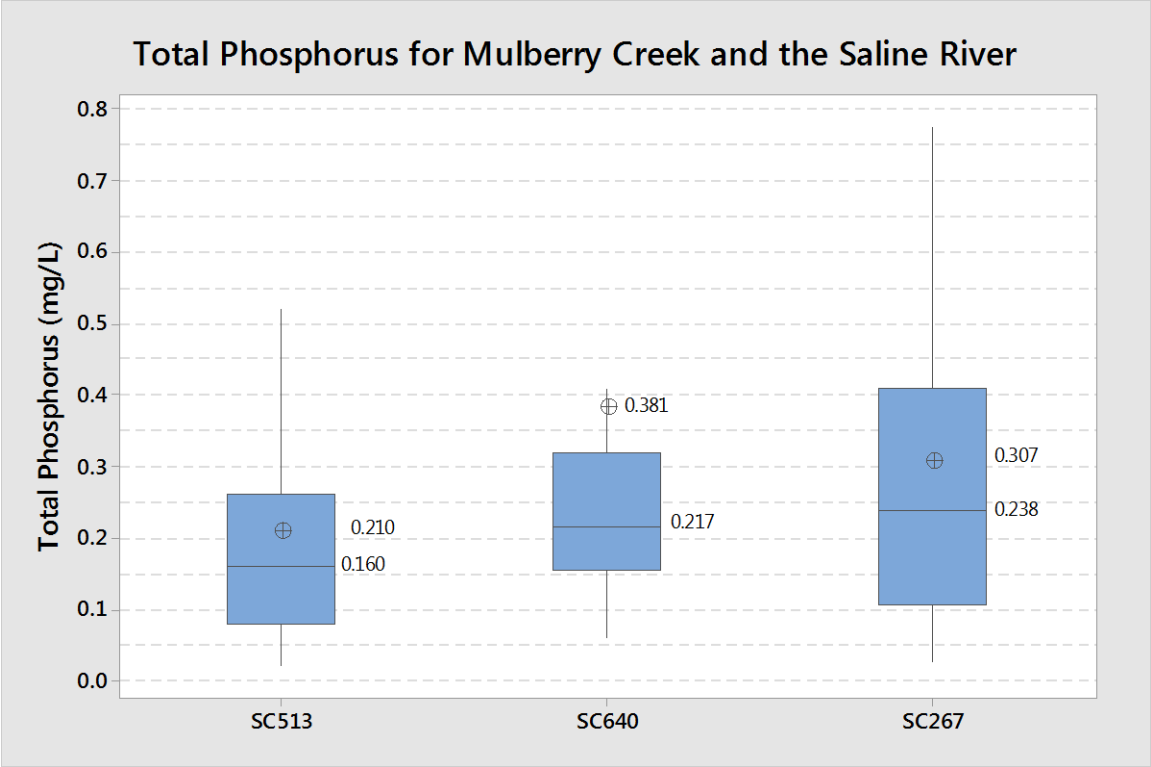


Figure 15. Total phosphorus by flow condition for Mulberry Creek near Salina (SC640).

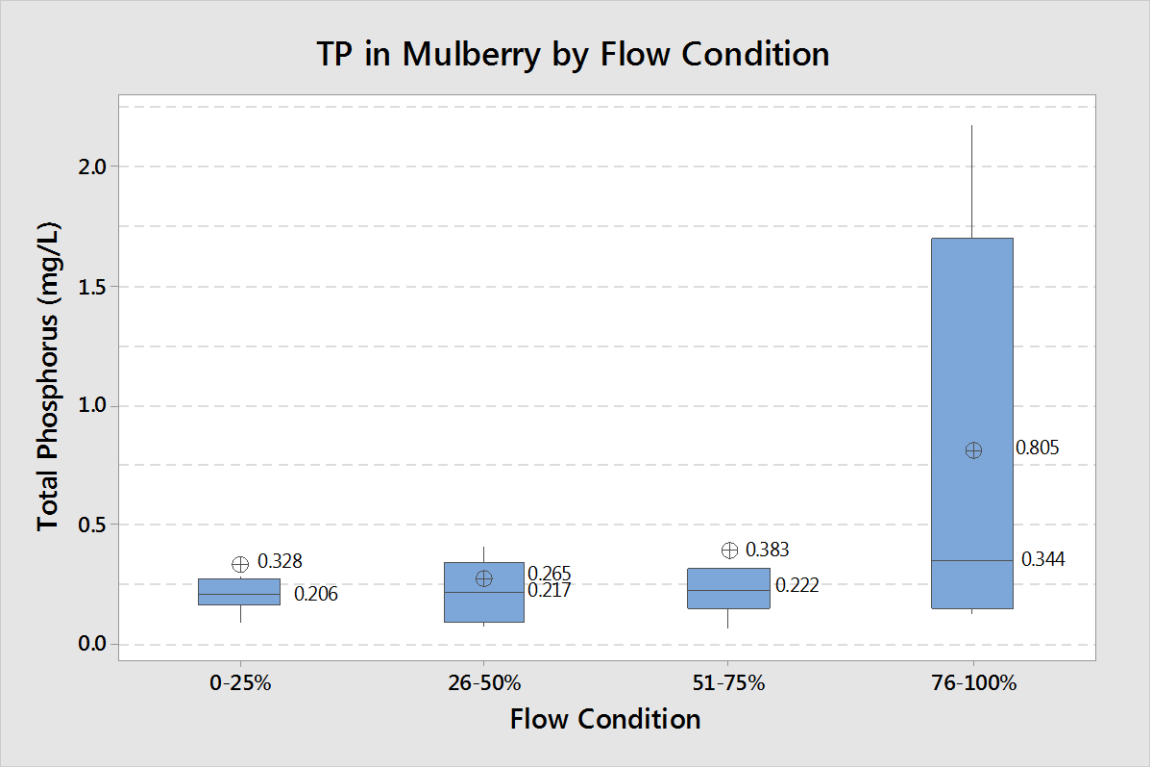
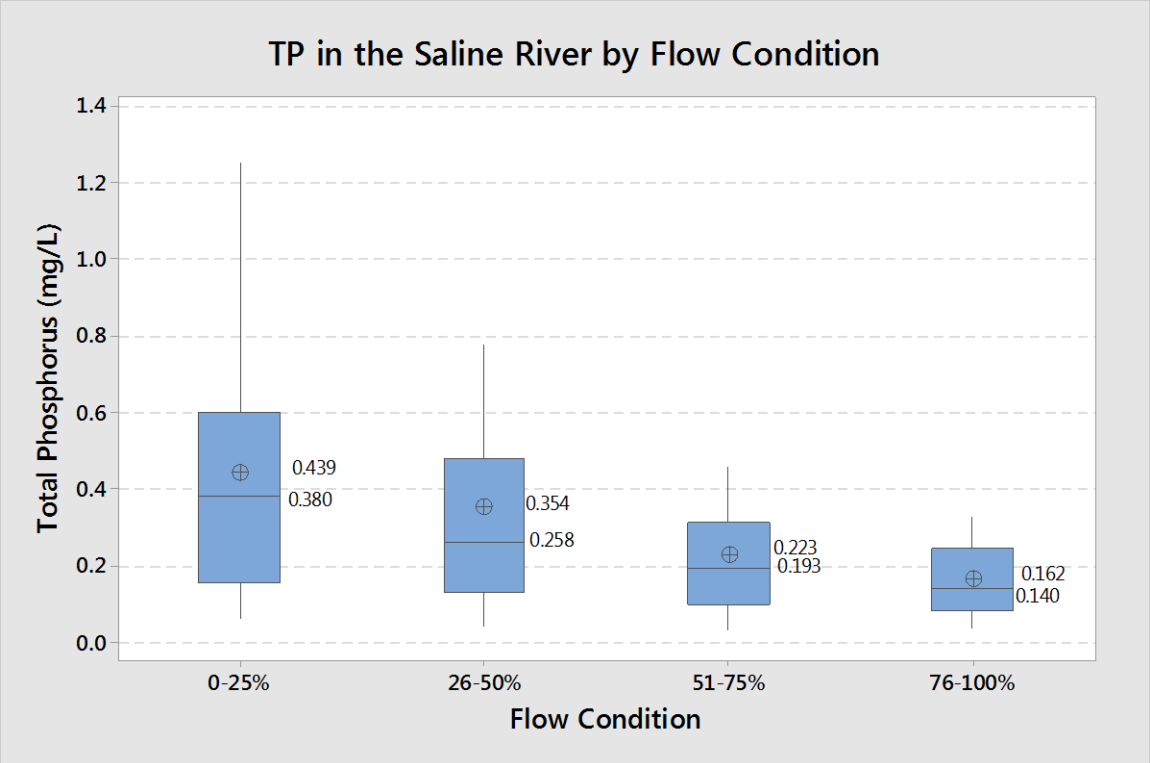


Figure 16. Total phosphorus by flow condition for the Saline River near New Cambria (SC267).



Throughout the period of record for Mulberry Creek (SC640), mean and median TP concentrations are higher during spring and summer-fall than in winter (**Figure 17**; **Table 6**). The Saline River (SC267) also shows mean and median TP concentrations higher during spring and summer-fall than in winter (**Figure 18**; **Table 7**). The seasons of spring and summer-fall typically have more precipitation and runoff events, which elevate TP concentrations due to nonpoint sources of TP loading.

Figure 17. Total phosphorus by season for Mulberry Creek near Salina (SC640).

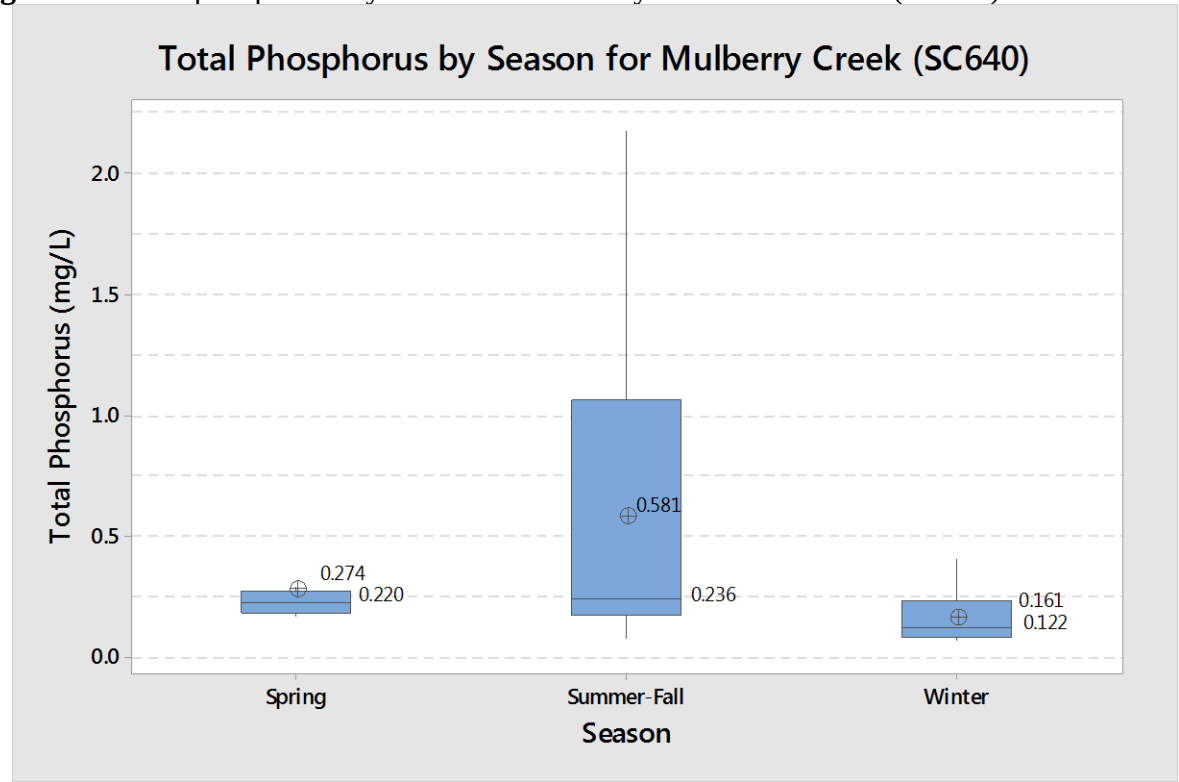


Figure 18. Total phosphorus by season for the Saline River near New Cambria (SC267).

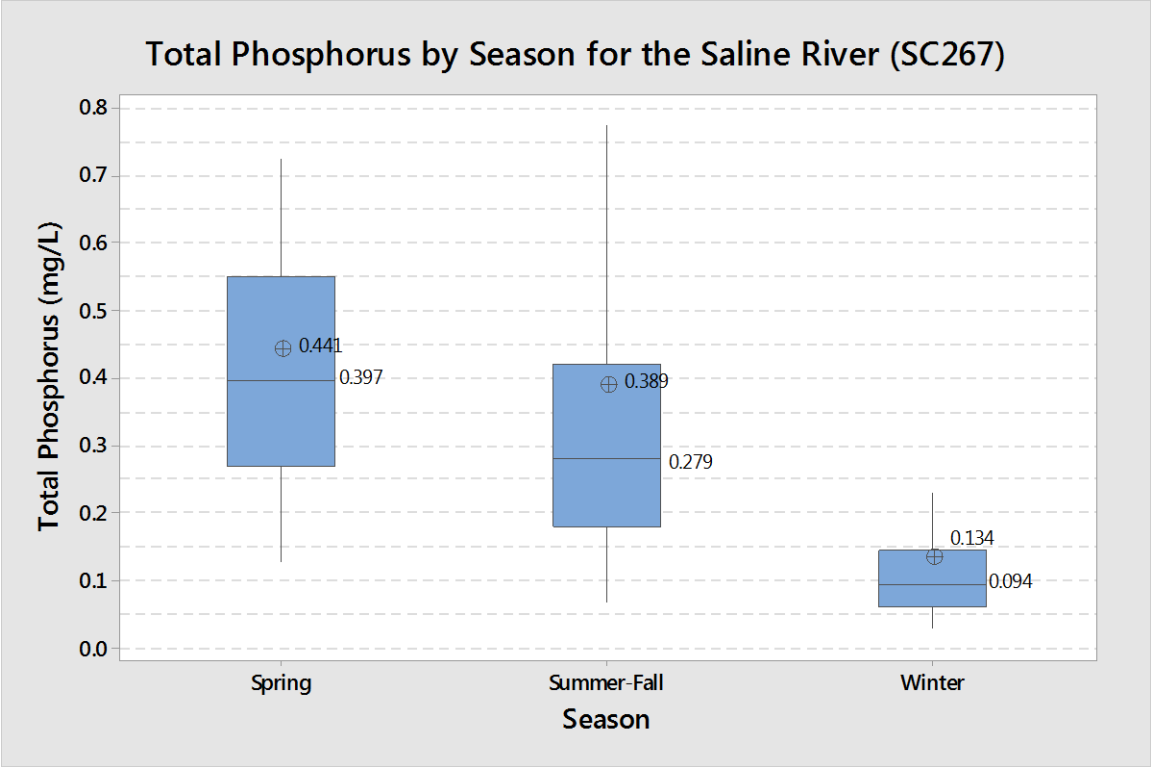


Figure 19 and **Figure 20** display single sample TP concentrations by flow condition and season. **Table 6** and **Table 7** display mean, median, maximum and minimum TP concentrations by season and flow condition. Throughout all flow conditions and seasons, mean and median TP concentrations typically remain below 0.5 mg/L in Mulberry Creek (SC640). Medians for the seasons range from 0.236-0.122 mg/L with the highest median, 0.236 mg/L, occurring in summer-fall at 0-100 % flow exceedance (**Table 6**). Throughout all seasons, mean and median TP concentrations for the Saline River (SC267) are highest during high flow conditions (0 to 25% flow exceedance; (**Table 7**). In general, TP concentrations in Mulberry Creek and the Saline River are higher during periods of higher flow condition (0-25%). For example, at the highest flow condition of 0-25% flow exceedance, SC267 mean and median TP concentrations are 0.439 and 0.380 mg/L, respectively; at 26-50% flow exceedance, SC267 mean and median TP concentrations are 0.357 and 0.258 mg/L, respectively (**Table 7**). Higher TP concentrations during higher flow conditions is indicative of nonpoint source and stormwater runoff.

Figure 19. Total phosphorus by percent flow exceedance and season for Mulberry Creek near Salina (SC640).

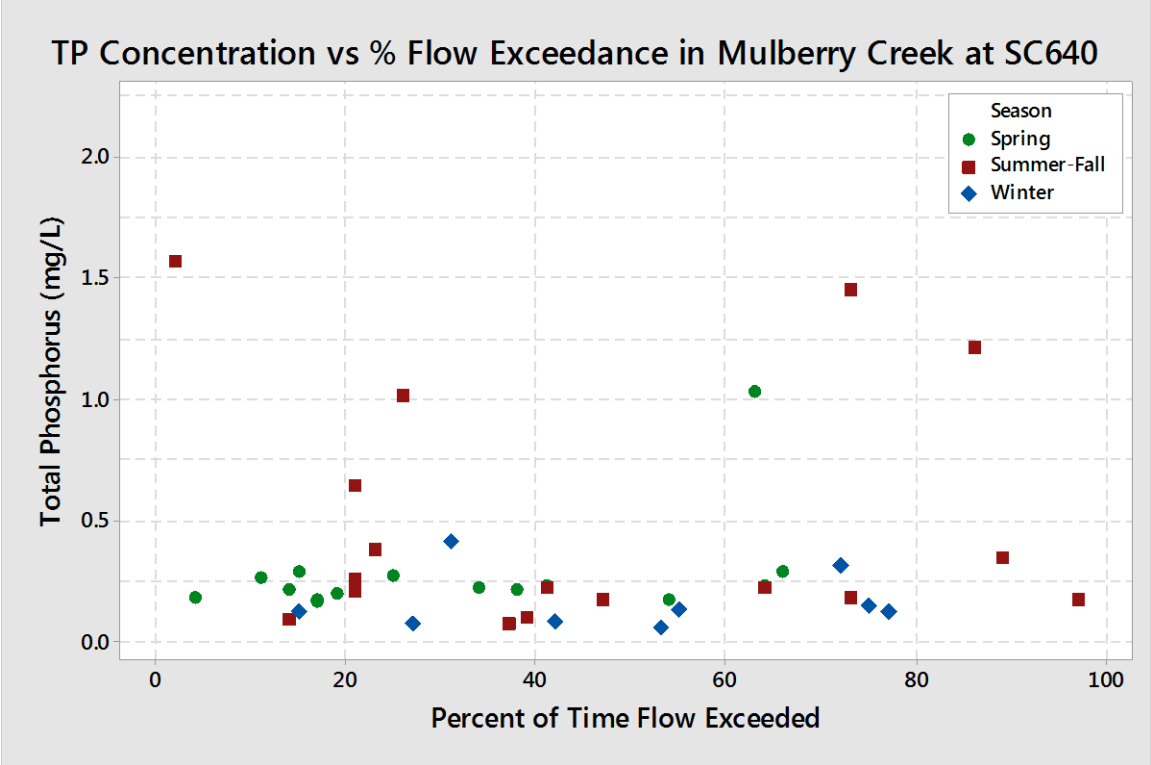


Figure 20. Total phosphorus by percent flow exceedance and season for the Saline River near New Cambria (SC267).

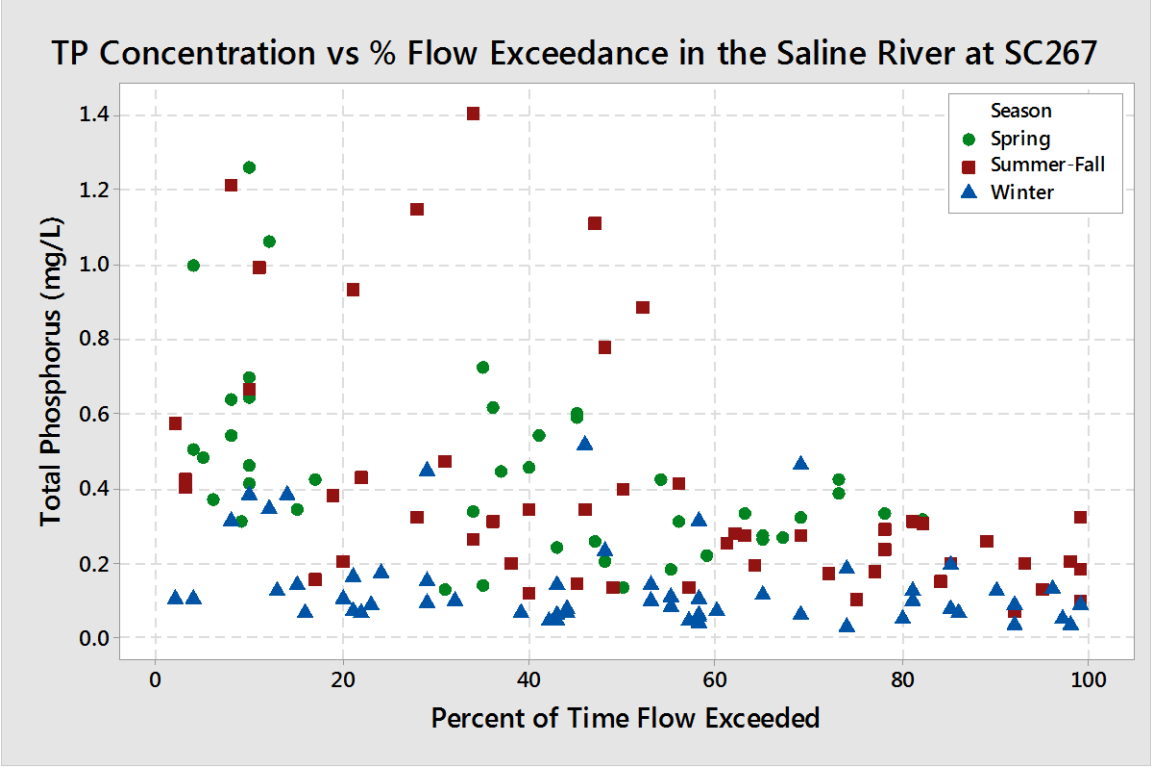


Table 6. Total phosphorus concentration mean, median, minimum, maximum, and number of samples (N) by season (spring: April through June, summer-fall: July through October, winter: November through March) and flow range for Mulberry Creek near Salina (SC640).

Flow Exceedance (%)	Total Phosphorus (mg/L)				
	Mean	Median	Minimum	Maximum	N
Spring					
0-25	0.221	0.210	0.159	0.284	7
26-50	0.221	0.220	0.214	0.230	3
51-75	0.430	0.259	0.172	1.03	4
76-100	0.180	0.180	0.180	0.180	1
0-100	0.274	0.220	0.159	1.03	15
Summer-Fall					
0-25	0.628	0.447	0.090	1.56	6
26-50	0.187	0.170	0.071	0.377	5
51-75	0.617	0.222	0.180	1.45	3
76-100	0.976	0.777	0.170	2.18	4
0-100	0.581	0.236	0.071	2.18	18
Winter					
0-25	0.096	0.096	0.071	0.120	2
26-50	0.245	0.245	0.080	0.409	2
51-75	0.154	0.130	0.059	0.310	5
76-100	-	-	-	-	-
0-100	0.161	0.122	0.059	0.409	9
All					
0-25	0.367	0.210	0.071	1.56	15
26-50	0.209	0.217	0.071	0.409	10
51-75	0.362	0.201	0.059	1.45	12
76-100	0.817	0.344	0.170	2.18	5
0-100	0.381	0.217	0.059	2.18	42

Definition: – - not applicable

Table 7. Total phosphorus concentration mean, median, minimum, maximum, and number of samples (N) by season (spring: April through June, summer-fall: July through October, winter: November through March) and flow range for the Saline River near New Cambria (SC267).

Flow Exceedance (%)	Total Phosphorus (mg/L)				
	Mean	Median	Minimum	Maximum	N
Spring					
0-25	0.607	0.500	0.310	1.257	15
26-50	0.386	0.392	0.217	0.724	14
51-75	0.307	0.310	0.1830	0.421	11
76-100	0.323	0.323	0.315	0.330	2
0-100	0.441	0.397	0.127	1.257	42
Summer-Fall					
0-25	0.576	0.428	0.151	1.209	11
26-50	0.497	0.340	0.118	1.400	15

Flow Exceedance (%)	Total Phosphorus (mg/L)				
	Mean	Median	Minimum	Maximum	N
51-75	0.295	0.260	0.100	0.882	10
76-100	0.207	0.194	0.0670	0.318	15
0-100	0.389	0.279	0.067	1.400	51
Winter					
0-25	0.172	0.120	0.063	0.388	15
26-50	0.154	0.090	0.040	0.512	13
51-75	0.120	0.087	0.027	0.459	16
76-100	0.086	0.084	0.033	0.190	13
0-100	0.137	0.094	0.027	0.512	57
All					
0-25	0.439	0.380	0.063	1.257	41
26-50	0.357	0.258	0.040	1.400	42
51-75	0.223	0.193	0.027	0.882	37
76-100	0.162	0.140	0.033	0.330	30
0-100	0.307	0.238	0.027	1.400	150

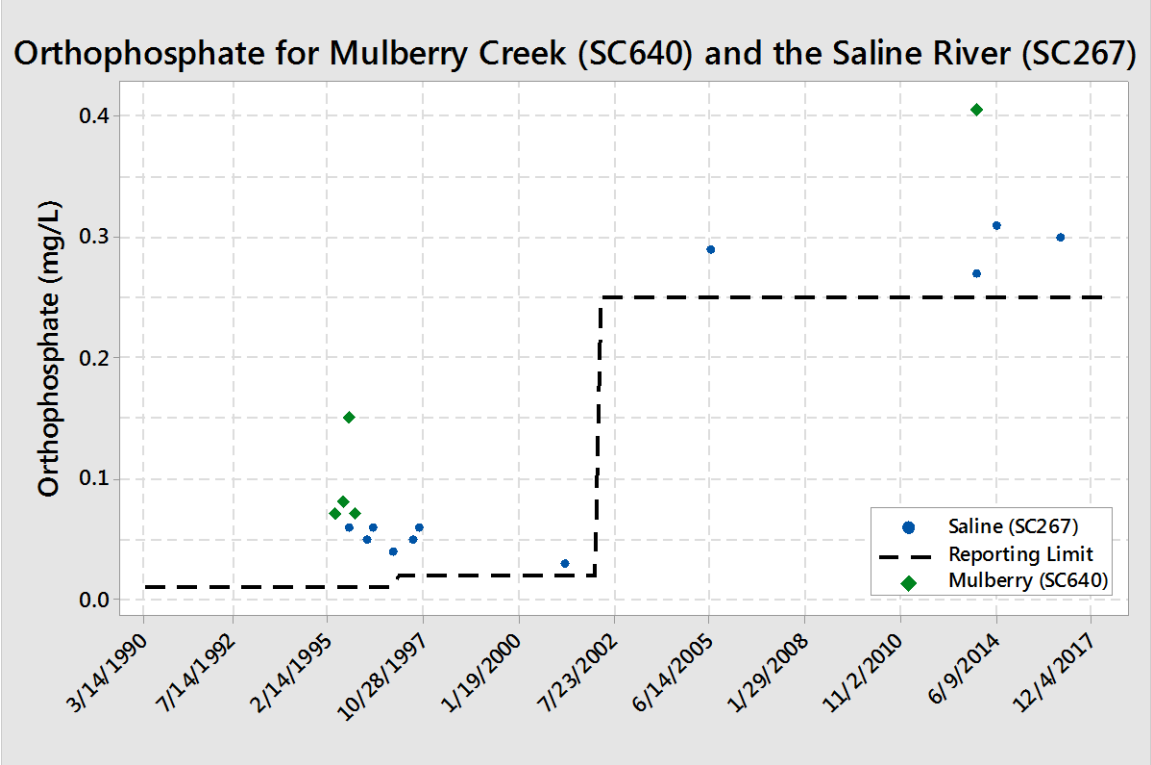
Total Phosphorus and Water Quality Parameters

Total phosphorus has well-established and defined relationships with orthophosphate (OP) and total suspended solids (TSS). These relationships are examined further to delineate potential sources of TP loading.

Orthophosphate

The soluble portion of TP that is readily available for biological use is OP. It is commonly found in higher concentrations in the discharge of municipal wastewater treatment plants (WWTPs), and can therefore be indicative of point source contributions of phosphorus in streams. Only samples measuring above the reporting limit are included in the analysis presented which may overestimate true OP concentration means. Reporting limits for OP have changed throughout the period of record: 0.01 mg/L from 1995-1996, 0.02 mg/L from 1997 to February 2002, and 0.25 mg/L from March 2002 to 2014. Mulberry Creek (SC640) has a total of five OP concentrations greater than the reporting limit, four of which occurred in 1995. Overall, 17% of all samples had OP concentrations greater than the reporting limit. The Saline River (SC267) has a total of 11 OP concentrations greater than the reporting limit, six of which occurred between 1995-1997. Overall, 11% of all samples had OP concentrations greater than the reporting limit (**Figure 21**).

Figure 21. Orthophosphate samples measuring greater than the reporting limit for Mulberry Creek (SC640) and the Saline River (SC267).



Total Suspended Solids

Phosphorus is typically linked to sediment or TSS because of the propensity of those solids to adsorb phosphorus. As seen in **Figure 22**, TSS levels on Mulberry Creek (SC640) show a positively correlated relationship between TP and TSS. However, the TP concentrations above 1.0 mg/L weaken this relationship. As seen in **Figure 23**, TSS levels on the Saline River (SC267) show a strong positively correlated relationship between TP and TSS.

Figure 22. Total phosphorus versus total suspended solids for Mulberry Creek near Salina (SC640).

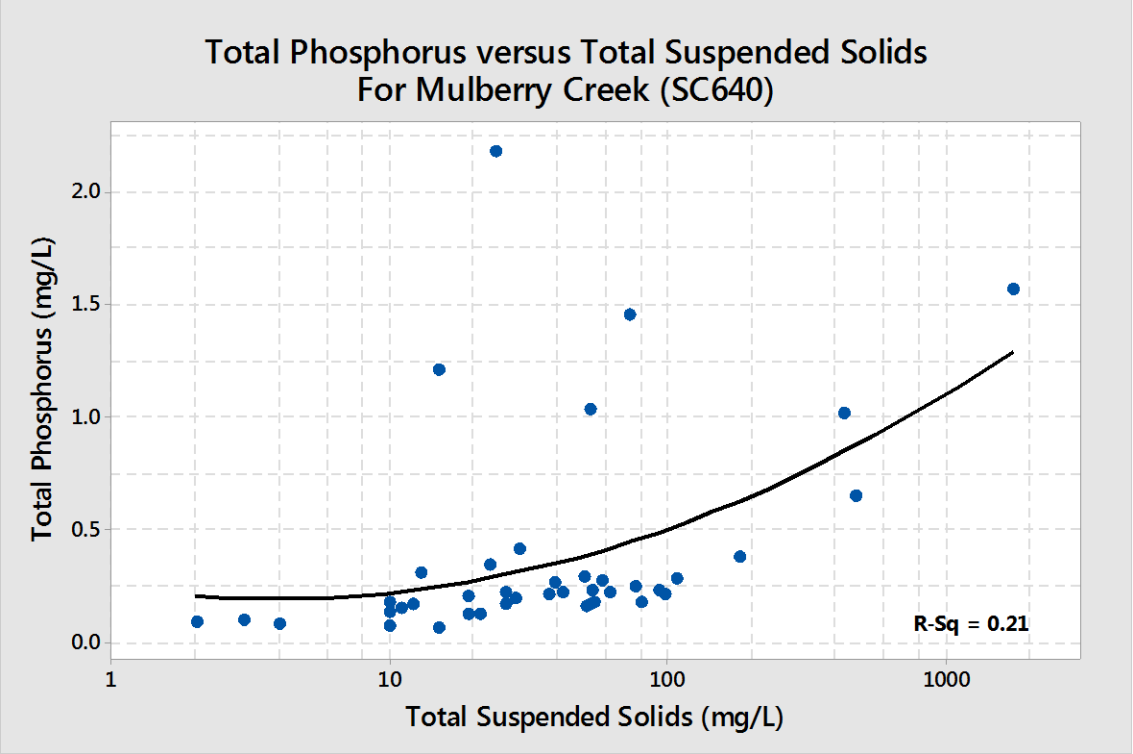
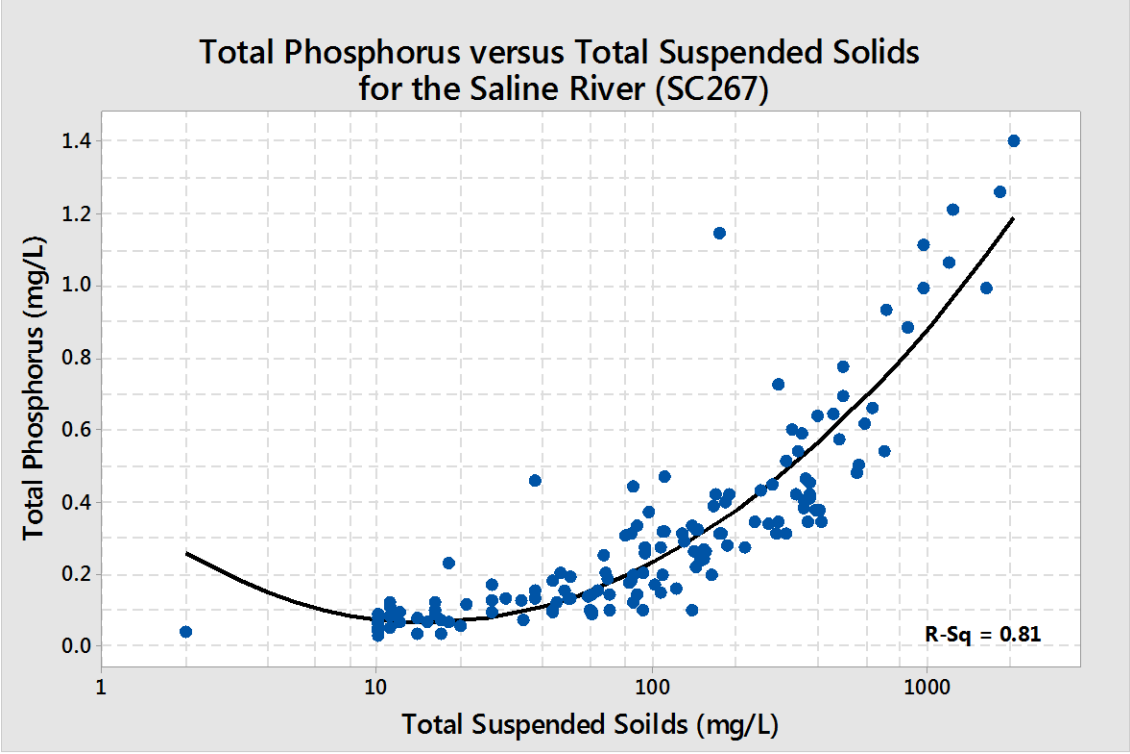


Figure 23. Total phosphorus versus total suspended solids for the Saline River near New Cambria (SC267).



Total Phosphorus and Biological Indicators

The narrative criteria of the Kansas Surface Water Quality Standards are based on conditions of the prevailing biological community. Excessive primary productivity may be indicated by extreme shifts in dissolved oxygen (DO), dissolved oxygen saturation (DO saturation), and pH as the chemical reactions of photosynthesis and respiration alter the ambient levels of oxygen and acid-base balance of the stream. These extreme shifts, in turn, can result in undesirable regime shifts in the algal biomass and biological community within the stream.

Dissolved Oxygen

Mulberry Creek (SC640) has two DO samples below the water quality criterion of 5 mg/L, the first occurred in April 1991 with a concentration of 3.8 mg/L and the second in September 2017 with a concentration of 4.0 mg/L (**Figure 24**). The Saline River (SC267) only has one DO sample below the water quality criterion occurring in June 2011 with a concentration of 3.55 mg/L (**Figure 25**). Dissolved oxygen and temperature are inversely related for Mulberry Creek (SC640) and the Saline River (SC267; **Figures 26-27**). This relationship is stronger in the Saline River (SC267). The relationship between DO and Temperature corresponds to seasonal changes in DO and temperature and is expected because oxygen becomes less soluble in water as temperatures increase (**Tables 8 -9**). Additionally, DO exhibits a diel trend due to daily fluctuations in photosynthetic activity. The presented data captures this daily variability based upon whether a sample was collected in the morning (7:31 am to 12:00 pm) or afternoon (12:00 to 19:04 pm); morning samples tend to have lower DO concentrations and afternoon samples tend to have higher DO concentrations. The Saline River (SC267) exhibits the diel trend, while Mulberry Creek (SC640) loosely exhibits the diel trend.

Figure 24. Dissolved oxygen by date for Mulberry Creek near Salina (SC640).

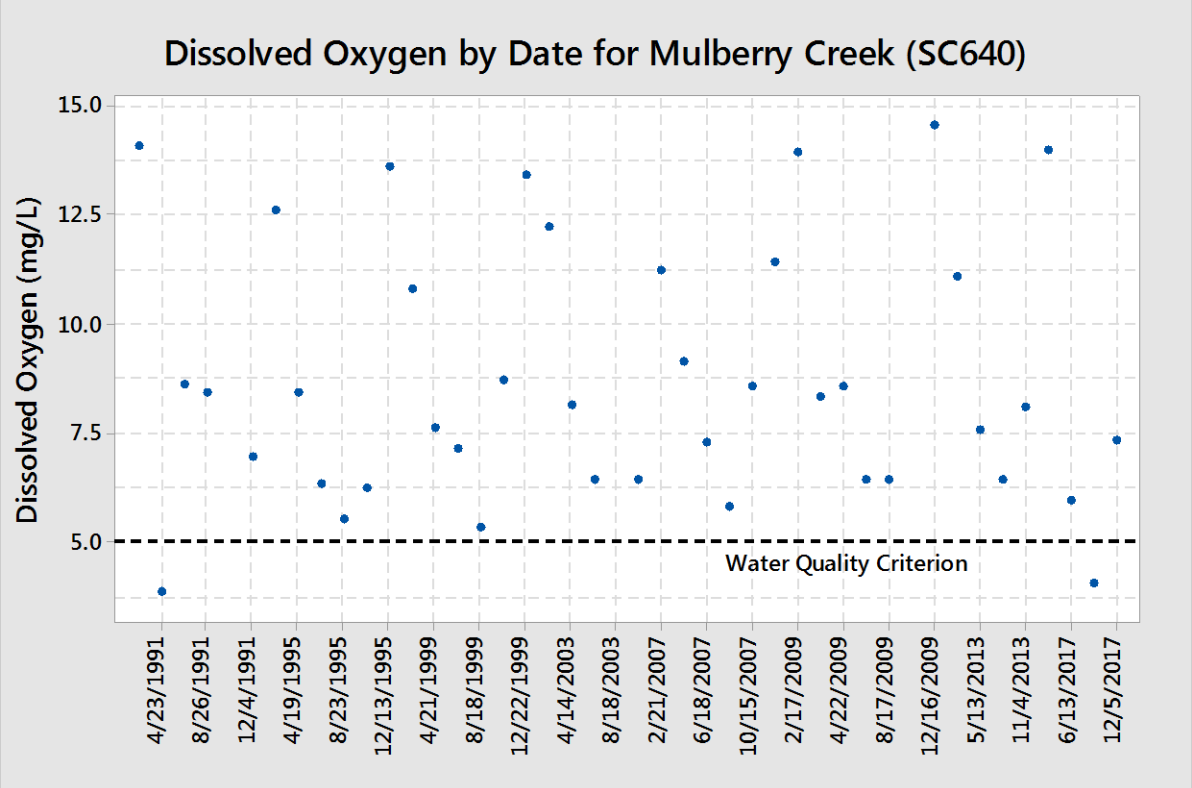


Figure 25. Dissolved oxygen by date for the Saline River near New Cambria (SC267).

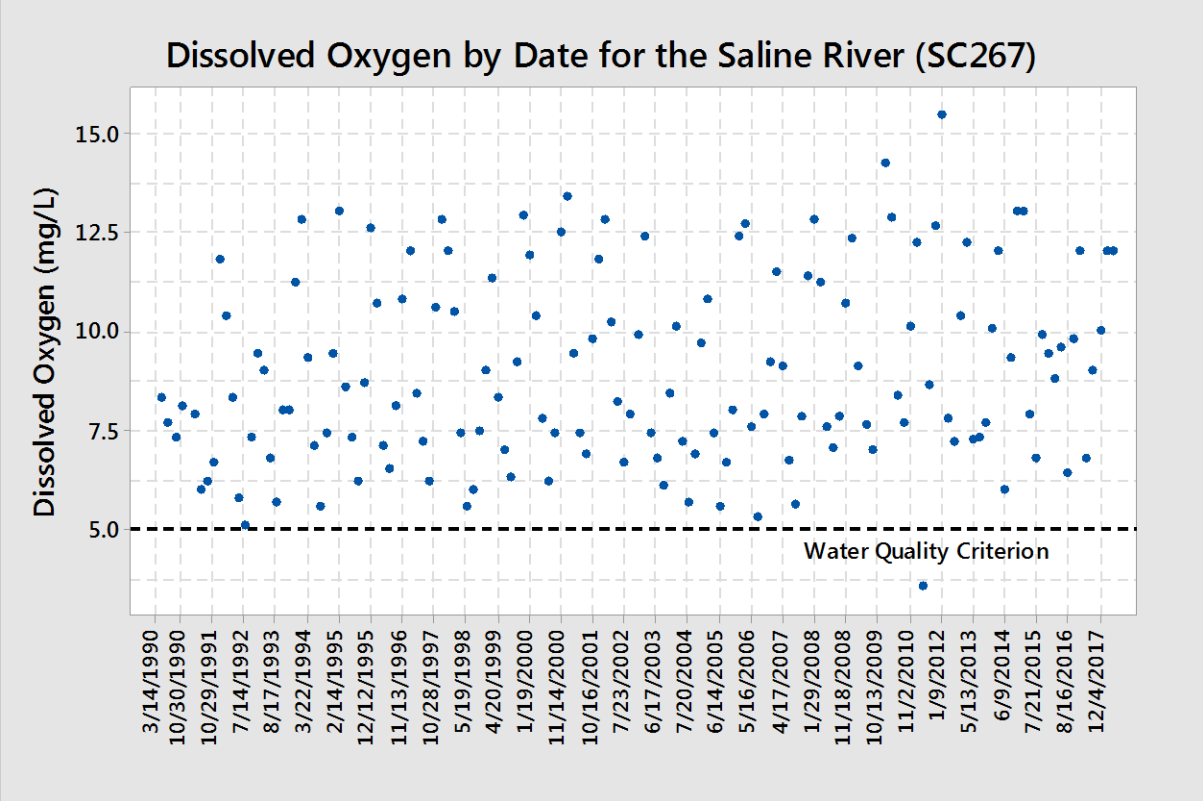


Figure 26. The relationship between dissolved oxygen and temperature for Mulberry Creek near Salina (SC640).

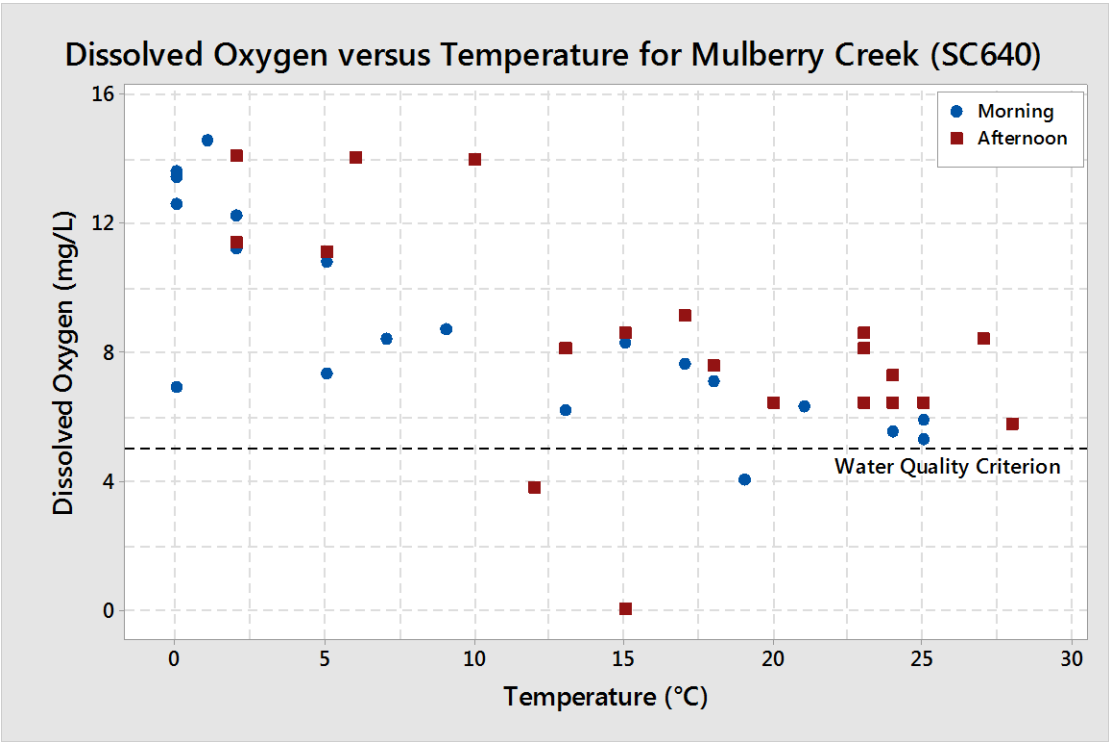


Figure 27. The relationship between dissolved oxygen and temperature for the Saline River near New Cambria (SC267).

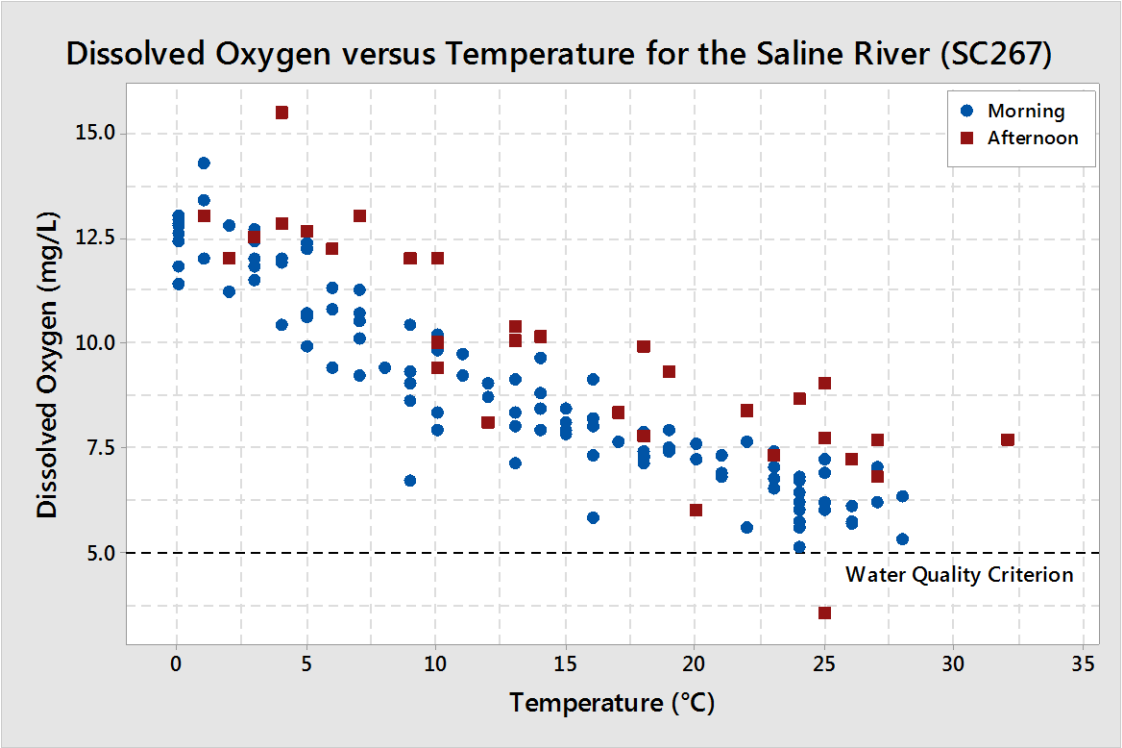


Table 8. Mean temperature, dissolved oxygen, and dissolved oxygen saturation, as well as median pH, by season for Mulberry Creek (SC640).

Water Quality Parameter	Season			
	Spring	Summer-Fall	Winter	All Seasons
Temperature (°C)	18.67	13.89	5.00	13.69
Dissolved Oxygen (mg/L)	7.29	7.71	12.00	8.48
Dissolved Oxygen Saturation (%)	77.81	65.92	87.76	77.97
pH	7.79	7.55	7.76	7.68

Table 9. Mean temperature, dissolved oxygen, and dissolved oxygen saturation, as well as median pH, by season for the Saline River (SC267).

Water Quality Parameter	Season			
	Spring	Summer-Fall	Winter	All Seasons
Temperature (°C)	18.17	20.59	5.19	14.06
Dissolved Oxygen (mg/L)	7.58	7.39	11.45	8.97
Dissolved Oxygen Saturation (%)	71.96	72.23	113.66	87.73
pH	7.81	7.87	7.84	7.84

Dissolved Oxygen Saturation

Primary productivity increases in the spring and summer-fall, when temperatures are higher and DO concentrations are lower. When primary productivity is excessive, oxygen from aquatic photosynthesis can create DO concentrations that exceed the natural oxygen equilibrium of the stream at a given temperature. Supersaturated conditions occur when the ratio of the oxygen capacity of the stream at a given temperature to the oxygen concentration in the stream exceeds 110%. Because of the system's diel characteristics, supersaturated conditions are more likely to be detected in the afternoon when photosynthesis and temperatures are at their peak. However, Mulberry Creek (SC640) displays this pattern. Throughout the period of record, Mulberry Creek (SC640) has two DO saturation values greater than 110% occurring once in 2009 and once in 2017 (**Figure 28**). However, this pattern is not displayed in the higher afternoon saturation values in the Saline River (SC267; **Figure 29**). There are 34 saturation values greater than 110% occurring in the Saline River (SC267).

Figure 28. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature for Mulberry Creek near Salina (SC640).

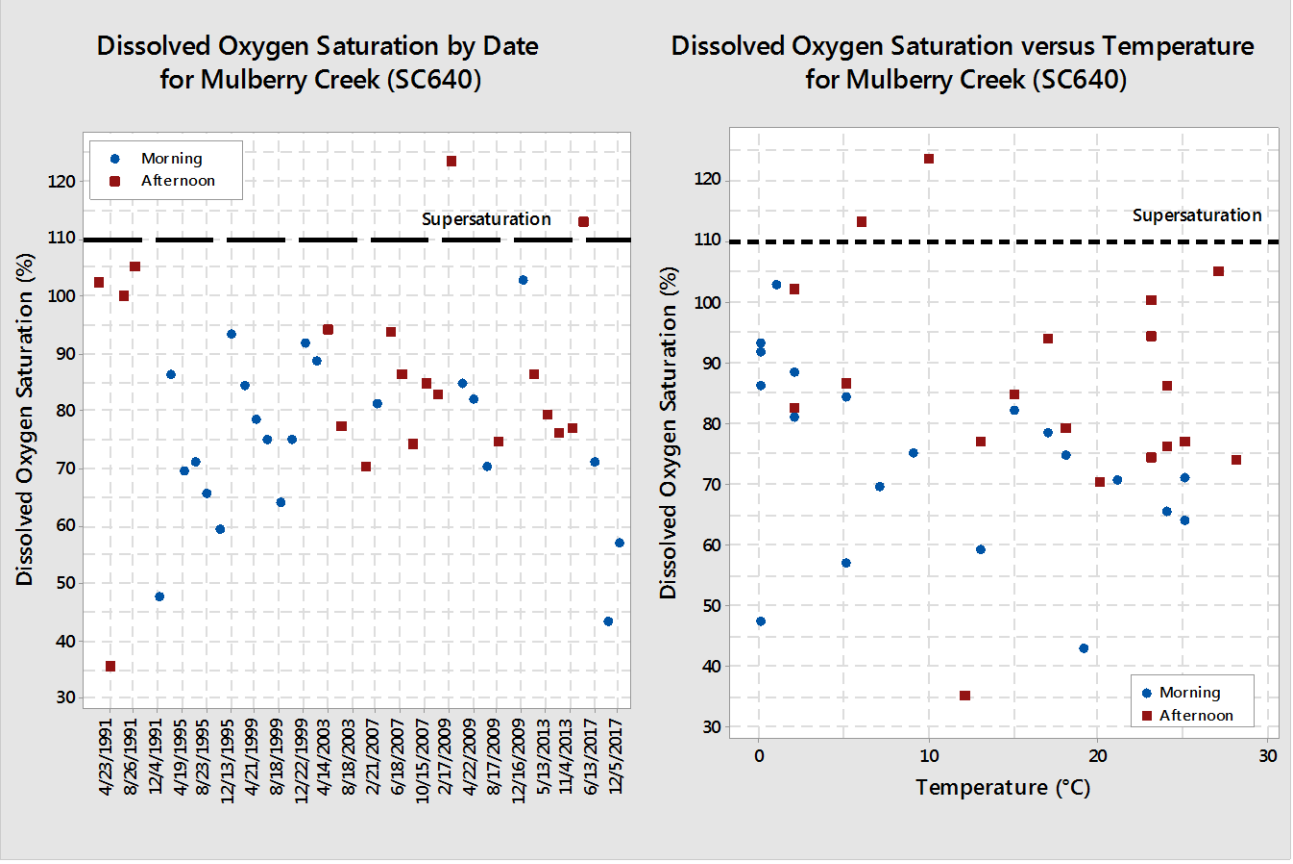
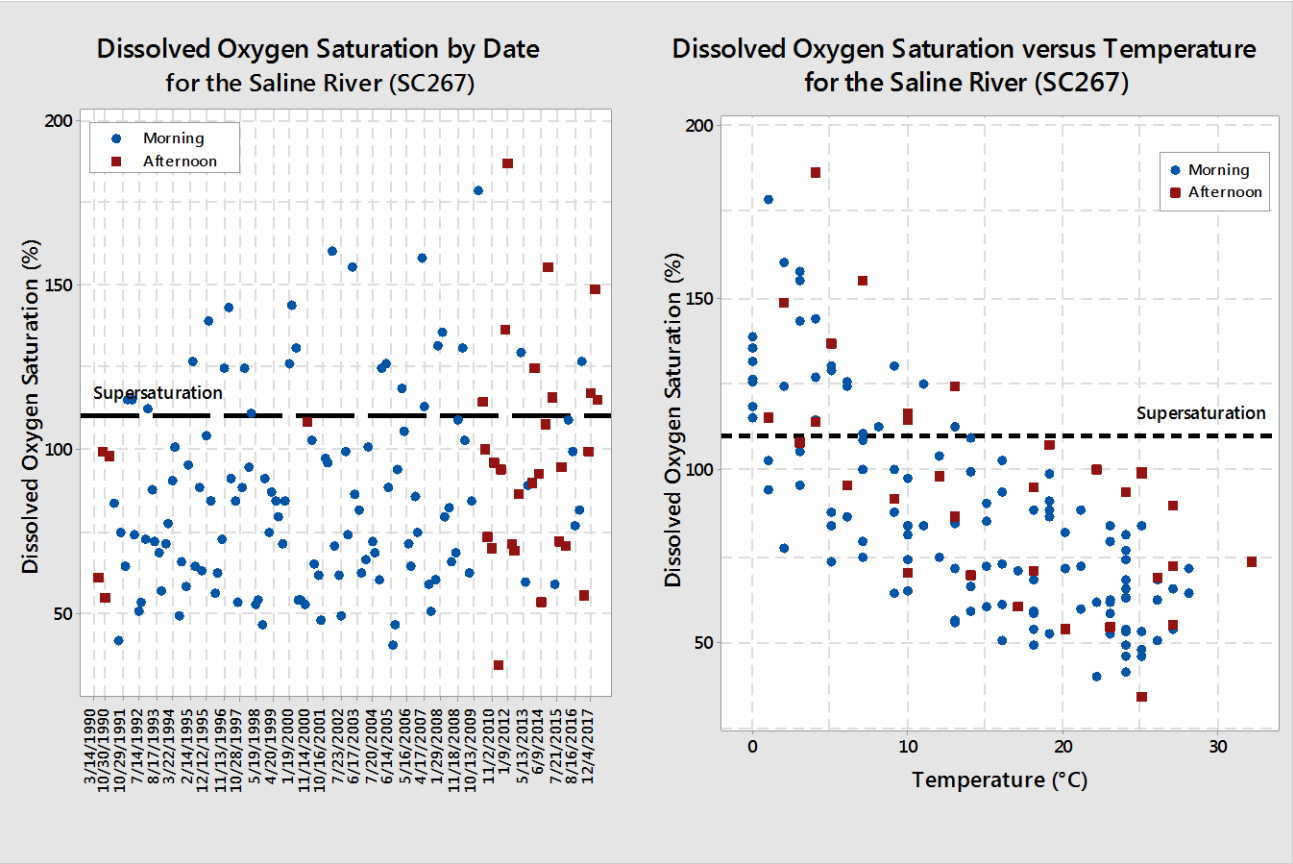


Figure 29. Dissolved oxygen saturation and the relationship between dissolved oxygen saturation and temperature for the Saline River near New Cambria (SC267).



pH

Another water quality indicator of primary productivity is pH, as photosynthesis can increase pH by removing carbon dioxide from the water. The numeric water quality criteria for pH is a range from 6.5 to 8.5. There is one pH excursion for Mulberry Creek (SC640) that occurred in February 1991 (**Figure 30**). There are no pH excursions for the Saline River (SC267; **Figure 31**).

Figure 30. The pH and the relationship between pH and temperature for Mulberry Creek near Salina (SC640).

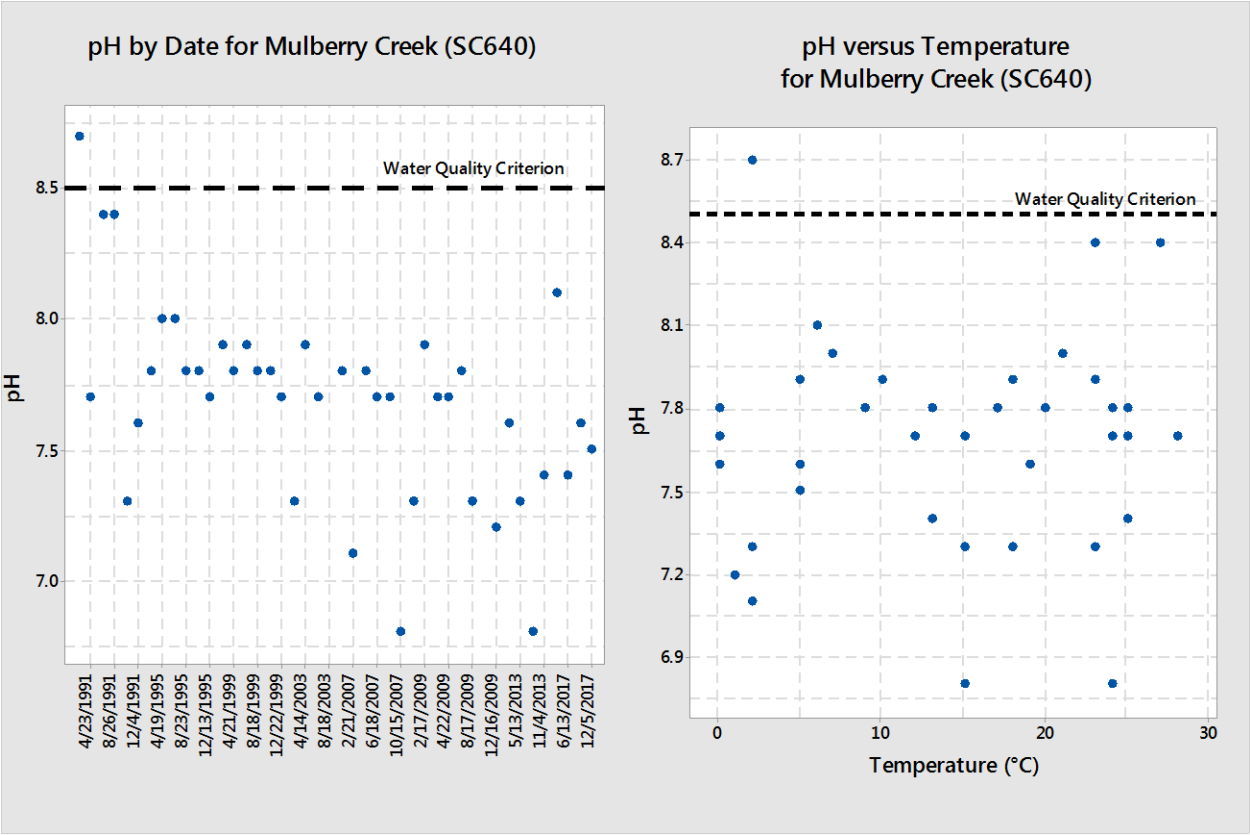
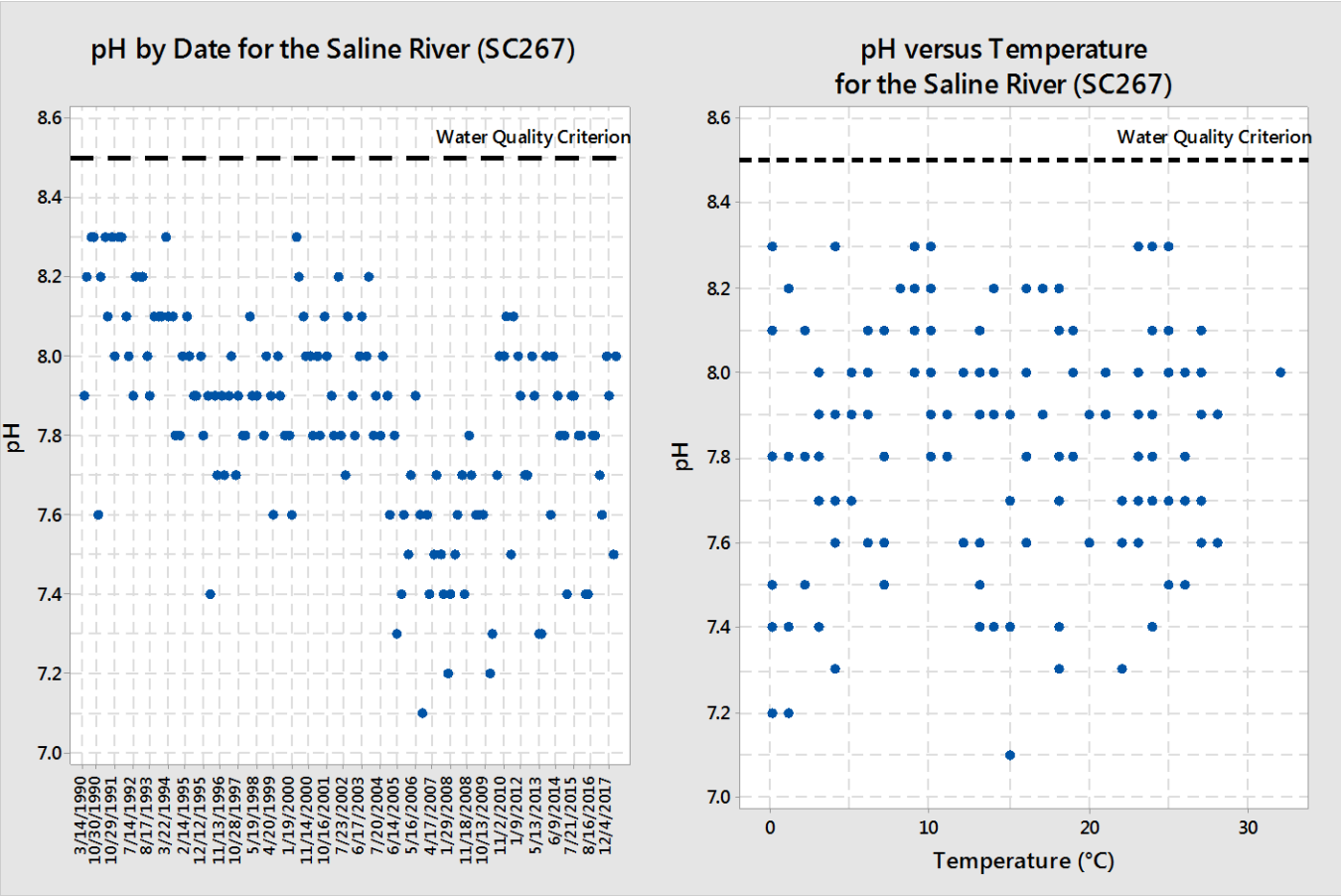


Figure 31. The pH and the relationship between pH and temperature for the Saline River near New Cambria (SC267).



Data regarding macroinvertebrate organisms and community are collected at KDHE stream biology (SB) stations. SB267 is co-located with SC267 in the Saline River watershed. KDHE's Stream Biological Monitoring Program uses the Aquatic Life Use Support Index (ALUS Index) to assess stream biology as described in Kansas' 2018 303(d) Methodology. The ALUS Index consists of five categorizations of biotic condition that, once measured, are assigned a score (**Table 11**). Scores are then tallied, and a support category is assigned according to **Table 12.**

1. Macroinvertebrate Biotic Index (MBI): A statistical measure that evaluates the effects of nutrients and oxygen demanding substances on macroinvertebrates based on the relative abundance of certain indicator taxa (orders and families).
2. Ephemeroptera, Plecoptera, and Trichoptera (EPT) abundance as a percentage of the total abundance of macroinvertebrates.
3. Kansas Biotic Index for Nutrients (KBI-N): Mathematically equivalent to the MBI, however, the tolerance values are species specific and restricted to aquatic insect orders.
4. EPT Percent of Count (EPT % CNT): The percentage of organisms in a sample consisting of individuals belonging to the EPT orders.
5. Shannon's Evenness (SHN EVN): A measure of diversity that describes how evenly distributed the numbers of individuals are among the taxa in a sample.

Table 11. ALUS Index metrics with scoring ranges.

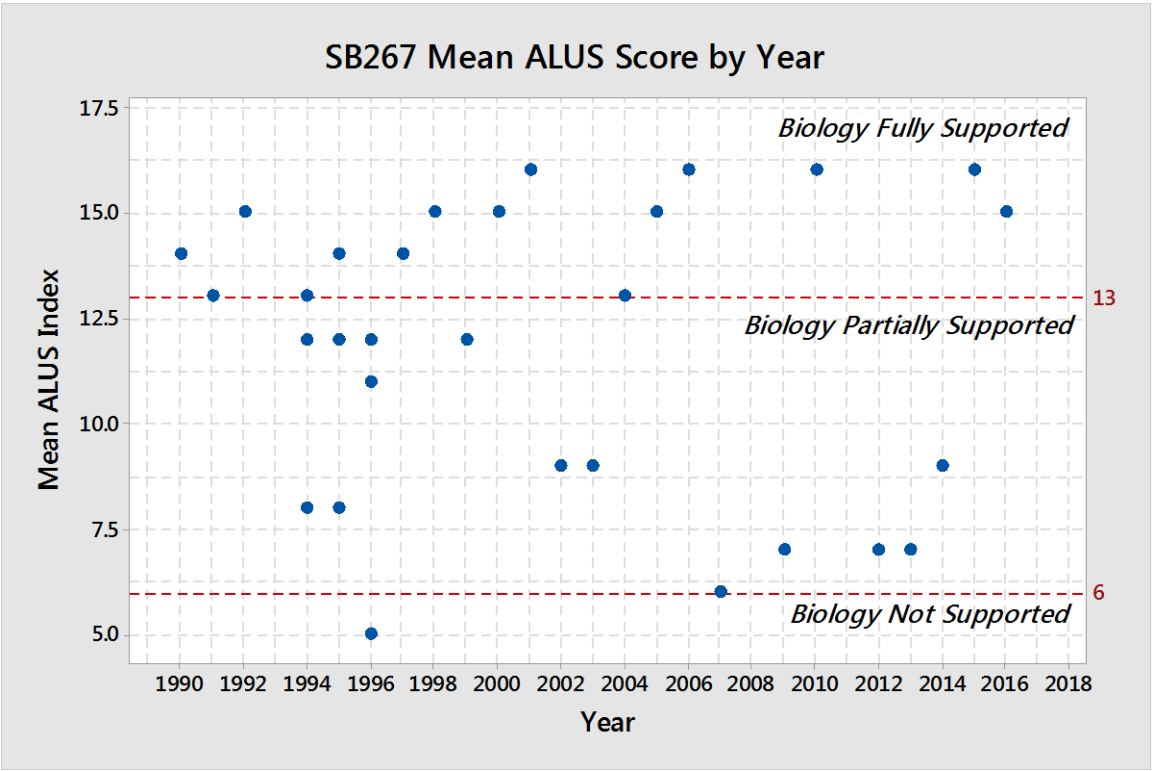
MBI	KBI-N	EPT	EPT % CNT	SHN EVN	Score
<= 4.18	<= 2.52	>= 16	>= 65	>= 0.849	4
4.19-4.38	2.53-2.64	14-15	56-64	0.826-0.848	3
4.39-4.57	2.65-2.75	12-13	48-55	0.802-0.825	2
4.58-4.88	2.76-2.87	10-11	38-47	0.767-0.801	1
>= 4.89	>= 2.88	< = 9	<= 37	<= 0.766	0

Table 12. ALUS Index score range, interpretation of biotic condition, and supporting, partial, and non-supporting categories.

ALUS Index Score	Biotic Condition	Support Category
>16 - 20	Very Good	Supporting
>13 - 16	Good	
>7 - 13	Fair	Partially Supporting
>3 - 6	Poor	Non-Supporting
0 - 3	Very Poor	

Biotic conditions were sampled annually on the Saline River (SB267) from 1990 to 2016. The Saline River (SB267) station has a total of 30 samples with a mean ALUS Index Score of 12, indicating biotic conditions are fair and partially supportive of aquatic life (**Figure 32**).

Figure 32. Aquatic Life Use Support Index scores in the Smoky Hill River from Mentor to Junction City, 1990 to 2016.



Desired Endpoint: The ultimate desired water quality endpoints of this TMDL will be to achieve the Kansas Water Quality Standards by eliminating the impacts to aquatic life, domestic water supply, and contact recreation associated with excessive phosphorus and objectionable flora as described in the narrative criteria pertaining to nutrients. There are currently no existing numeric phosphorus criteria in Kansas. The U.S. EPA suggested benchmark for stream TP in the South Central Cultivated Great Plains Nutrient Ecoregion V is 0.067 mg/L over the ten-state aggregate of Level III ecoregions.

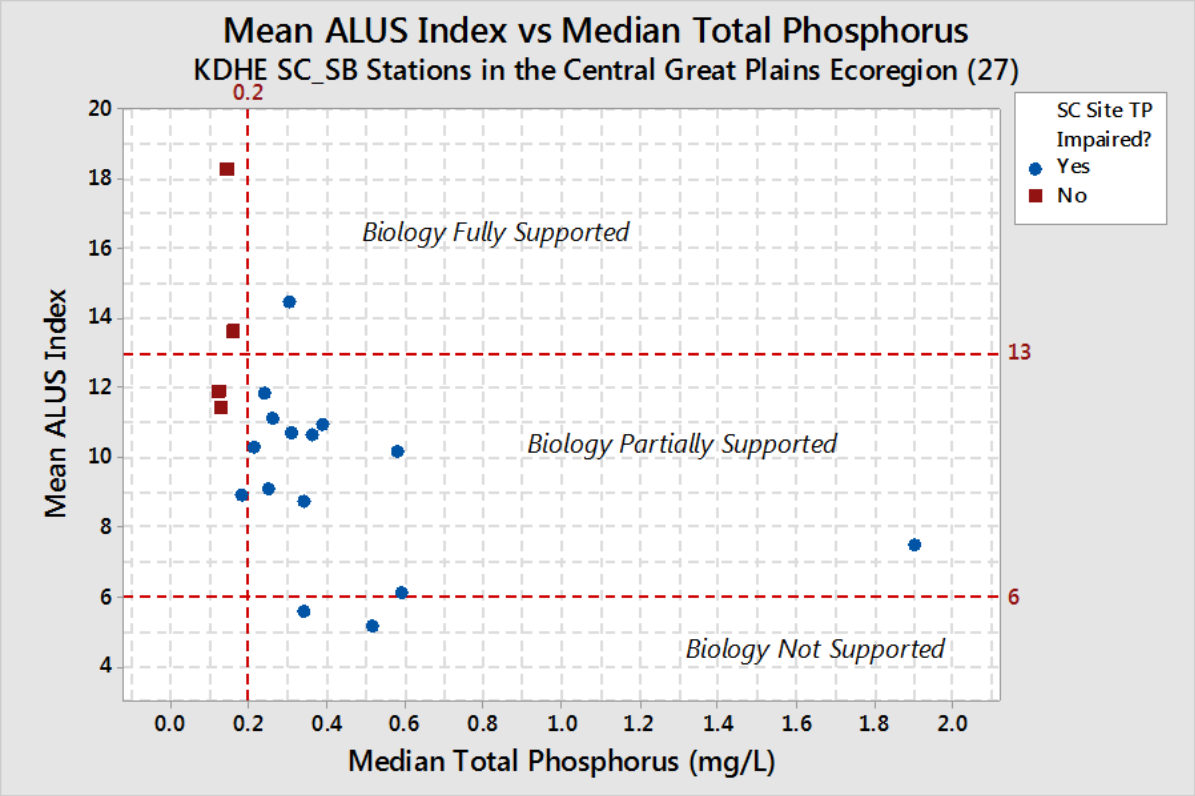
The Mulberry Creek and the Saline River watershed lies within U.S. EPA Level IV Ecoregion of the Central Great Plains (27). Assessment of TP data from the 129 KDHE monitoring stations located in the Central Great Plains ecoregion for the 2000 through 2018 period of record was used to establish TP milestones for the TMDL included in this document.

Table 10. TP summary data of ecoregion 27 stream chemistry stations located in Kansas for total phosphorus, 2000-April 2018.

USEPA Ecoregion	Number of KDHE Stations	Number of Samples	25th Percentile of Medians (mg/L)	50th Percentile of Medians (mg/L)	75th Percentile of Medians (mg/L)
Central Great Plains	129	7,248	0.130	0.200	0.374

Figure 33 displays the relationship between median phosphorus values and ALUS Index scores within the Central Great Plains (27) Ecoregion. Higher ALUS Index scores are indicative of higher quality biological communities. There are 19 KDHE monitoring stations located in the Central Great Plains (27) Ecoregion that have corresponding biology and TP datasets over the 1990 through 2016 period of record. When median TP concentrations are compared to the mean ALUS Index for those stations, the resulting plot reveals three stations as fully supporting biology with median TP values ranging from 0.140 to 0.300 mg/L, while stations partially supporting biology have TP concentrations ranging from to 0.180 to 1.90 mg/L. The three stations in the ecoregion currently unimpaired for TP have a mean ALUS Index of 15.4; meanwhile, the impaired stations on the 303(d) list for TP demonstrate less support for biology with a mean ALUS Index of 9.4.

Figure 33. Median total phosphorus (TP) versus mean Aquatic Life Use Score (ALUS) Index for stream chemistry/stream biology (SC/SB) stations located in Kansas' Central Great Plain Ecoregion (27) from 1990 through 2016.



The greatest complication in setting an endpoint is establishing the linkage of phosphorus levels to applicable biologic response variables. Displayed in **Figure 33** is a noisy relationship between the ALUS Index and phosphorus that defies establishing a solitary threshold value and supports an adaptive management approach to reduce current phosphorus loads and concentrations; this adaptive management approach requires observing and responding to improvement in biological metrics and sestonic chlorophyll *a* prior to further reductions. Therefore, the primary measure of reduction in nutrient loading to the impaired segments in the TMDL watershed will be the ALUS Index. The ALUS Index will serve to establish if the biological community at the SB stations in the watershed reflect recovered, renewed diversity and minimal disruption by the impacts described in the narrative criteria for nutrients on aquatic life, recreation, and domestic water supply.

Additionally, the concentration of floating sestonic phytoplankton in the water column at SC267 and SC640 as determined by measuring the sestonic chlorophyll *a* concentrations in the Saline River and Mulberry Creek will indicate if primary productivity has moderated to reduce the impacts described in the narrative criteria for nutrients on aquatic life, recreation, and domestic water supply along the reaches of the Saline River and Mulberry Creek.

Secondary indicators of the health of the in-stream biological community include:

1. Dissolved oxygen concentrations greater than 5.0 mg/L and the percent dissolved oxygen not more than 110%. Percent dissolved oxygen saturation is the measure of oxygen in the water relative to the water's potential dissolved oxygen concentration. Dissolved oxygen concentrations below 5.0 mg/L put aquatic life under stress while dissolved oxygen percent saturation levels greater than 110% are indicative of over-active primary productivity.
2. Instream pH values remain below 8.5. Excessive nutrients can induce vigorous photosynthesis which will cause pH to rise above 8.5, the current Kansas criterion.

Therefore, the numeric endpoints for this TMDL indicating attainment of water quality standards within the watershed are:

1. An ALUS Index score greater than 13 at SB stations.
2. Maintain median sestonic chlorophyll *a* concentration equal to or below 10 µg/L at SC stations.
3. Dissolved oxygen concentrations greater than 5.0 mg/L at SC stations.
4. Dissolved oxygen saturation below 110% at SC stations.
5. pH values within the range of 6.5 to 8.5 at SC stations.

All five endpoints have to be initially maintained over three consecutive years to constitute full support of the designated uses of the Saline River and Mulberry Creek. After the endpoints are attained, simultaneous digression of these endpoints more than once every three years on average constitutes a resumption of impaired conditions in the stream unless the TP impairment is delisted through the 303(d) process.

There are no existing numeric phosphorus criteria currently in Kansas. Hence, the series of endpoints established by this TMDL will be the measures used to indicate full support of the designated uses for the creek and river. These endpoints will be evaluated periodically as phosphorus levels decline in the watershed over time with achievement of the ALUS Index endpoint indicating restored status of the aquatic life use in the river.

This TMDL looks to establish phased total phosphorus endpoints that will be the cue to examine for altered, improved biological conditions in the creek and river. Assessment of the biological community in the watershed will be initiated once concentrations approach the Phase I management milestone of a median concentration of 0.200 mg/L, representing the 50th percentile of the median TP concentrations for stream chemistry stations located in the Level III ecoregion of the Central Great Plains (27). Should the biological community fail to respond to Phase I reductions in total phosphorus, Phase II will commence with a TP milestone of a median concentration of 0.130 mg/L, representing the lower quartile of the median TP concentrations for stream chemistry stations located in the Level III Ecoregion of the Central Great Plains (27). Simultaneous achievement of the chlorophyll *a*, dissolved oxygen, oxygen saturation, and pH endpoints will signal phosphorus reductions are addressing the accelerated succession of aquatic biota and the development of objectionable concentrations of algae and algae byproducts thereby restoring the domestic water supply, aquatic life, and contact recreation uses in the creek.

Table 13. Total Phosphorus (TP) at current condition (1990 through 2017) and Phase I and Phase II TP milestones for Mulberry Creek and the Saline River.

Stream Chemistry Station	Current Condition	TMDL Phase I		TMDL Phase II	
	Median TP (mg/L)	TP Milestone (mg/L)	Reduction in TP from Current Concentration	TP Milestone (mg/L)	Reduction in TP from Current Concentration
Mulberry Creek near Salina (SC640)	0.217	0.200	8%	0.130	40%
Saline River near New Cambria (SC267)	0.238	0.200	16%	0.130	45%

3. SOURCE INVENTORY AND ASSESSMENT

Point Sources

There are a total of 14 National Pollution Discharge Elimination System (NPDES) permits in the Mulberry Creek and Saline River watersheds (**Table 14**). Of the 14 permitted facilities, 11 are located in to the Mulberry Creek watershed (SC640) and 3 are in the Saline River watershed (SC267). Of the 14 permitted facilities, six are non-discharging lagoons, one is a federal non-discharging lagoon, one is an industrial groundwater remediation site, two are ready-mix plants and four are municipal discharging lagoons. There is one Municipal Separate Storm Sewer System (MS4) permit in the Mulberry Creek and Saline River Watershed for the city of Salina.

Table 14. National Pollution Discharge Elimination System (NPDES) facilities in the Mulberry Creek and Saline River Watershed.

Permitee	Kansas Permit Number	NPDES Permit Number	Facility Type	Receiving Stream	Permit Expiration	Monitoring Frequency	Current Flow (MGD)	Design Flow (MGD)	Current TP Mean (mg/L)
Mulberry Creek (SC640)									
Ralph Luther Moblie Home Park	C-SA20-NO01	KSJ000178	Non-Discharging Lagoon	NA	2/29/2020	NA	NA	NA	NA
Rolling Hills Wildlife Adventure	C-SA20-NO03	KSJ000212	Non-Discharging Lagoon	NA	1/31/2020	NA	NA	NA	NA
Sundowner, INC. MHP	C-SA20-NO04	KSJ000133	Non-Discharging Lagoon	NA	1/31/2020	NA	NA	NA	NA
KOA of Salina	C-SH33-NO02	KSJ000544	Non-Discharging Lagoon	NA	2/29/2020	NA	NA	NA	NA
St. Francis Community & Family Services	C-SH49-NO01	KSJ000530	Non-Discharging Lagoon	NA	12/31/2020	NA	NA	NA	NA

Permitee	Kansas Permit Number	NPDES Permit Number	Facility Type	Receiving Stream	Permit Expiration	Monitoring Frequency	Current Flow (MGD)	Design Flow (MGD)	Current TP Mean (mg/L)
Smoky Hill Weapons Range	F-SH33-NO01	KSJ000522	Federal Non-Discharging Lagoon	NA	12/31/2020	NA	NA	NA	NA
Bunge Groundwater Remediation	I-SA20-PO04	KS0100196	Industrial Groundwater Remediation	Saline River via Mulberry Creek via pipe	7/31/2021	Current permit does not require TP monitoring	0.059	0.54	0.06
City of Brookville	M-SA02-OO01	KS0096831	Discharging Lagoon	West Spring Creek	12/31/2019	Quarterly	No Data	0.0374	No discharge on record
Sundowner West Meadows	M-SA20-OO01	KS0094161	Discharging Lagoon	Mulberry Creek via Unnamed Tributary	9/30/2019	Quarterly	No Data	0.011	No discharge on record
Smoky Valley Concrete	I-SA20-PR03	KSG110077	Ready Mix Plant	Unnamed Tributary to Dry Creek to Mulberry Creek	9/30/2022	NA	NA	NA	NA
Builders Choice Concrete-Salina	I-SA20-PR01	KSG110050	Ready Mix Plant	Dry Creek	9/30/2022	NA	NA	NA	NA
Saline River (SC267)									
City of Beverly	M-SA01-OO01	KS0095141	Discharging Lagoon	Saline River via Unnamed Tributary	6/30/2019	Quarterly	No Data	0.035	No discharge on record
Tescott MWTP	M-SA17-OO01	KS0025691	Discharging Lagoon	Saline River	9/30/2019	Quarterly	No Data	0.0476	3.14
KDOT - Ottawa Co. Rest Area	M-SO27-NO01	KSJ000296	Non-Discharging Lagoon	NA	5/31/2020	NA	NA	NA	NA

Definitions: NA - not applicable

There are seven non-discharging lagoons. Two of these are two-cell lagoon systems operated by the Ralph Luther Mobile Home Park and KDOT - Ottawa Co. Rest Area, and both are prohibited from discharging. KOA of Salina also has a two-cell lagoon system that is prohibited from discharging but only one cell is in operation. Rolling Hills Wildlife Adventure and St. Francis Community & Family Services are three-cell lagoon system. Sundowner, INC. MHP is a five-cell lagoon system. Additionally, there is a federal non-discharging lagoon operated by Smoky Hill Weapons Range that has one two-cell lagoon system and one one-cell lagoon system. Prohibited from discharging by their NPDES permits, these systems do not monitor for TP and are not expected to contribute the TP impairment in the watershed.

There are two ready mix plants: Smoky Valley Concrete and Builders Choice Concrete- Salina. Smoky Valley Concrete Both is a permanent dry batch concrete plant. Builders Choice Concrete-Salina is a permanent dry batch ready-mix concrete operation. Concrete plants are authorized to

discharge. These facilities do not monitor for TP and are not expected to contribute to the TP impairment in the watershed.

The facility implementing groundwater remediation is Bunge Groundwater Remediation. Currently, there are two outfalls for this facility but only one outfall has data. Outfall 001X1 discharges on average 0.059 million gallons per day (MGD). The current permit for this facility does not require TP monitoring. However, there is a sample from the facility recorded in 2014 at 0.06 mg/L TP. The Bunge Groundwater Remediation is assigned a TP wasteload allocation (WLA) under this TMDL.

The four municipal discharging lagoons within the watershed are operated by the City of Brookville, City of Beverly, Tescott Municipal Wastewater Treatment (MWPT), and Sundowner West Meadows. All four facilities treat domestic waste in a three-cell lagoon system. They are required to collect and report TP data quarterly, when discharging; however, they are currently not required to report the discharge volume. Only Tescott MWPT has reported TP data, with a mean of 3.14 mg/L TP, but has no data for flow. The City of Brookville, City of Beverly, and Sundowner West Meadows do not have any discharging data. All discharging lagoons will also be assigned a TP WLA under this TMDL.

Municipal Separate Storm Sewer System

There is one permitted MS4 entity within the Mulberry Creek and Saline River Watershed. The City of Salina has an MS4 and a portion of the city lies in this both Mulberry and the and the Saline River watersheds therefore, there is an allocated an MS4 stormwater load.

Livestock and Waste Management Systems

There are 32 certified or permitted Confined Animal Feeding Operations (CAFOs) within the Saline River and Mulberry Creek Watershed (**Figure 1**; **Table 15)**. Only one of these facilities is large enough to require a federal permit. All of these livestock facilities have waste management systems designed to retain an anticipated two weeks of normal wastewater from their operations and contain a 25-year, 24-hour rainfall/runoff event, as well. Typically, this rainfall event coincides with streamflow that occurs less than 1-5% of the time. Additionally, facility waste management systems are designed to minimize runoff entering operations and detain runoff emanating from operations. It is unlikely TP loading would be attributable to properly operating permitted facilities, though extensive loading may occur if any of these facilities were in violation and discharged. All CAFOs within this TMDL watershed are assigned a TP WLA of 0.

Table 15. Confined Animal Feeding Operations in the Saline and Mulberry Creek Watershed.

Kansas Permit Number	County	Livestock Type	Livestock Total	Permit Type	Federal Permit
A-SALC-BA10	Lincoln	Beef	100	Certification	-
A-SALC-BA14	Lincoln	Beef	300	Certification	-
A-SALC-MA02	Lincoln	Dairy	70	Certification	-
A-SALC-BA13	Lincoln	Beef	300	Certification	-
A-SALC-BA17	Lincoln	Beef	600	Certification	-
A-SAOT-BA04	Ottawa	Beef	200	Certification	-
A-SAOT-BA01	Ottawa	Beef	100	Certification	-
A-SAOT-BA03	Ottawa	Beef	60	Certification	-
A-SAOT-MA01	Ottawa	Dairy	35	Certification	-
A-SAOT-BA06	Ottawa	Beef	300	Certification	-
A-SAOT-BA02	Ottawa	Beef	200	Certification	-
A-SAOT-BA05	Ottawa	Beef	300	Certification	-
A-SAOT-BA08	Ottawa	Beef	300	Certification	-
A-SAOT-BA07	Ottawa	Beef, Swine	110	Certification	-
A-SASA-BA06	Saline	Beef	500	Certification	-
A-SALC-SA02	Lincoln	Swine	100	Certification	-
A-SASA-BA04	Saline	Beef	300	Certification	-
A-SASA-BA15	Saline	Beef	150	Certification	-
A-SASA-BA16	Saline	Beef	200	Certification	-
A-SASA-BA08	Saline	Beef	180	Certification	-
A-SASA-BA02	Saline	Beef	900	Certification	-
A-SASA-BA05	Saline	Beef	200	Certification	-
A-SASA-BA09	Saline	Beef	300	Certification	-
A-SASA-BA07	Saline	Beef	120	Certification	-
A-SASA-BA14	Saline	Beef	320	Certification	-
A-SASA-BA03	Saline	Beef	250	Certification	-
A-SAOT-C001	Ottawa	Beef	1100	Permit	KS0094625
A-SASA-B001	Saline	Beef	999	Permit	-
A-SASA-B003	Saline	Beef, Swine, Horses	544.4	Permit	-
A-SASA-B002	Saline	Beef	598	Permit	-
A-SAOT-K001	Ottawa	Kennel	100	Renewal	-
A-SASA-SA01	Saline	Swine	1400	Certification	-

The total number of livestock within Lincoln, Ottawa, and Saline counties are declining (**Table 16**; U.S. Department of Agriculture, 2012). The primary livestock industry is cattle, with cattle and calves numbering 31,692 in Lincoln County, 41,602 in Ottawa County, and 24,578 in Saline County in 2012. From 2007 to 2012, cattle and calves have declined by at least 14% in each county. However, there are some livestock that are increasing in these counties, such as poultry increases in Lincoln County and Ottawa County. Smaller livestock and winter feeding operations are located directly adjacent to Mulberry Creek on the contributing tributaries in the watershed may contribute significant nutrients particularly during runoff events.

Table 16. Agricultural census results for livestock in Lincoln, Ottawa, and Saline counties from 2007 and 2012 (U.S. Department of Agriculture, 2012).

Livestock	Lincoln 2007	Lincoln 2012	Ottawa 2007	Ottawa 2012	Saline 2007	Saline 2012
Cattle and Calves	45,610	31,692	48,787	41,602	34,581	24,578
Sheep and Lambs	450	381	281	744	2,020	2,123
Poultry	451	594	595	798	1,842	1,188
Hogs and Pigs	143	-	1,231	848	806	322
Goats	93	661	1,028	249	678	569
Total	**46,747**	**33,328**	**51,922**	**44,241**	**39,927**	**28,780**

Definition: – - data not available

Land Use

The total number of farms and acres of cropland declined in Ellsworth, Lincoln, Ottawa, and Saline counties between 2007 and 2012. In these counties there were 58 less farms in cropland and 17,842 less acres of cropland in 2012 than in 2007 (**Table 17**; U.S. Department of Agriculture, 2012). The 2011 National Land Cover Database shows the dominant land use is grassland (57.8%) and the secondary land use is cultivated crops (31.3%) in the watershed (**Table 18**; **Figure 34**; NLCD, 2011). Cultivated cropland has an increased potential for nutrient runoff from fertilizers, which can contribute to TP loads in the watershed. Additionally, 6.3% of the watershed is developed, with the most development occurring near Salina. Built infrastructure and impervious surfaces in urban environments increase runoff, which can potentially contribute to TP loads in the watershed, as well.

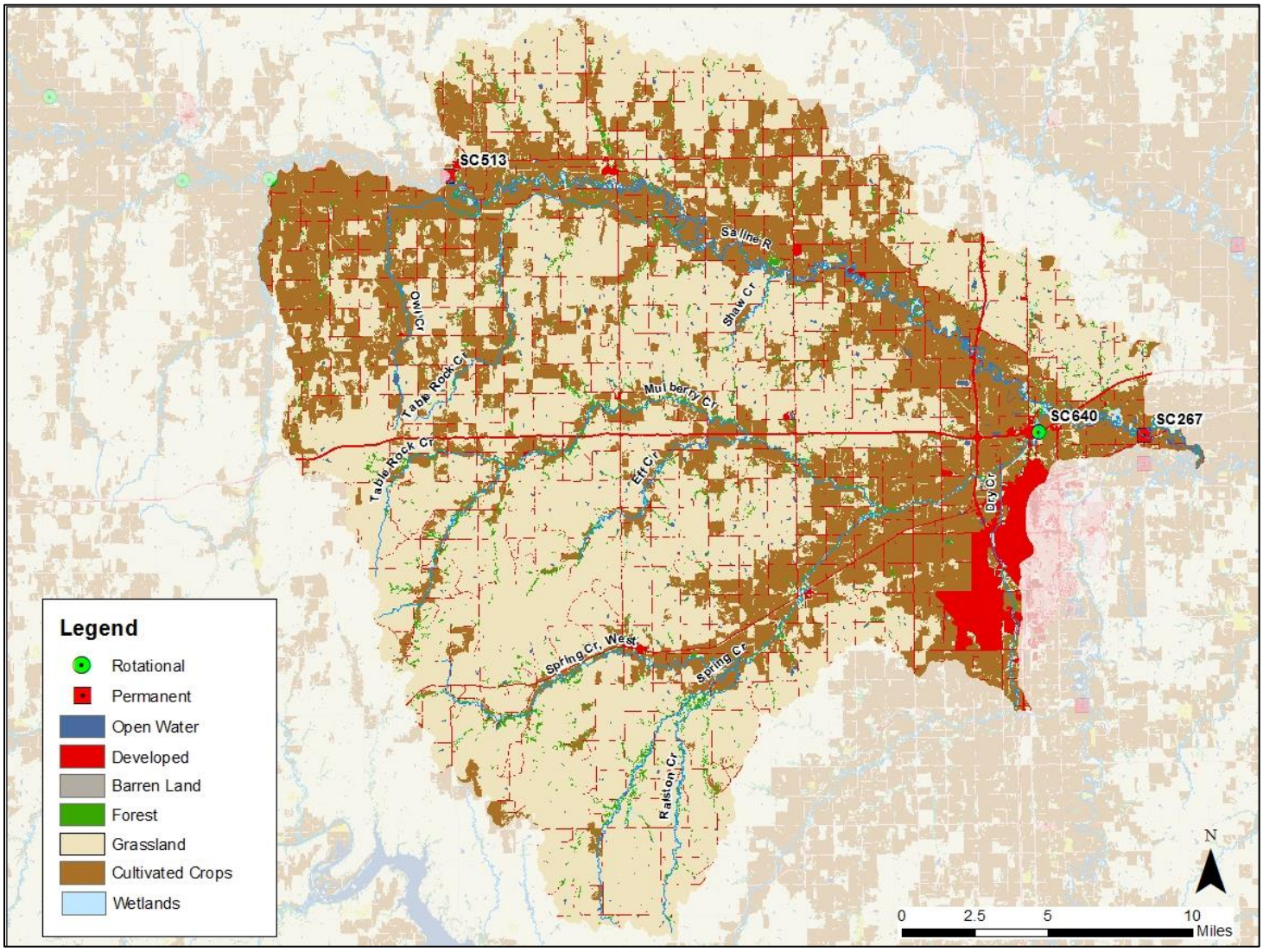
Table 17. Agricultural census results for farms and cropland in Ellsworth, Lincoln, Ottawa, and Saline counties from 2007 and 2012 (U.S. Department of Agriculture, 2012).

Year	Total Farms in Cropland 2007	Total Cropland (acres) 2007	Total Farms in Cropland 2012	Total Cropland (acres) 2012
Ellsworth	261	130,160	263	132,524
Lincoln	328	189,012	307	172,141
Ottawa	403	216,672	388	217,525
Saline	526	234,159	502	229,971
Total	**1,518**	**770,003**	**1,460**	**752,161**

Table 18. Land cover by percent in the Mulberry Creek and Saline River Watershed NLCD, 2011).

Land Use (percent)						
Open Water	Developed	Barren	Forest	Grassland	Cultivated Crops	Wetlands
1.0	6.3	0	2.8	57.8	31.3	0.8

Figure 34. Map of land cover in the Mulberry Creek and Saline River Watershed (NLCD, 2011).



Population Density

Population within the counties where the watershed lies is on the decline in Lincoln County and increasing in Ellsworth County, Ottawa County, and Saline County according to the 2000 and 2010 censuses (**Table 19**).

Table 19. County census results from 2000 and 2010 (U.S. Census Bureau, 2010) and population projections for 2040 (Kansas Water Office, 2002).

County	Population, 2000	Population, 2010	Population Projection, 2040	Population Change, 2000 to 2010 (%)
Lincoln	3,329	3,034	2,312	-8.9
Ellsworth	6,561	6,641	6,879	1.2
Ottawa	5,850	6,094	6,829	4.2
Saline	53,131	56,670	67,287	6.7

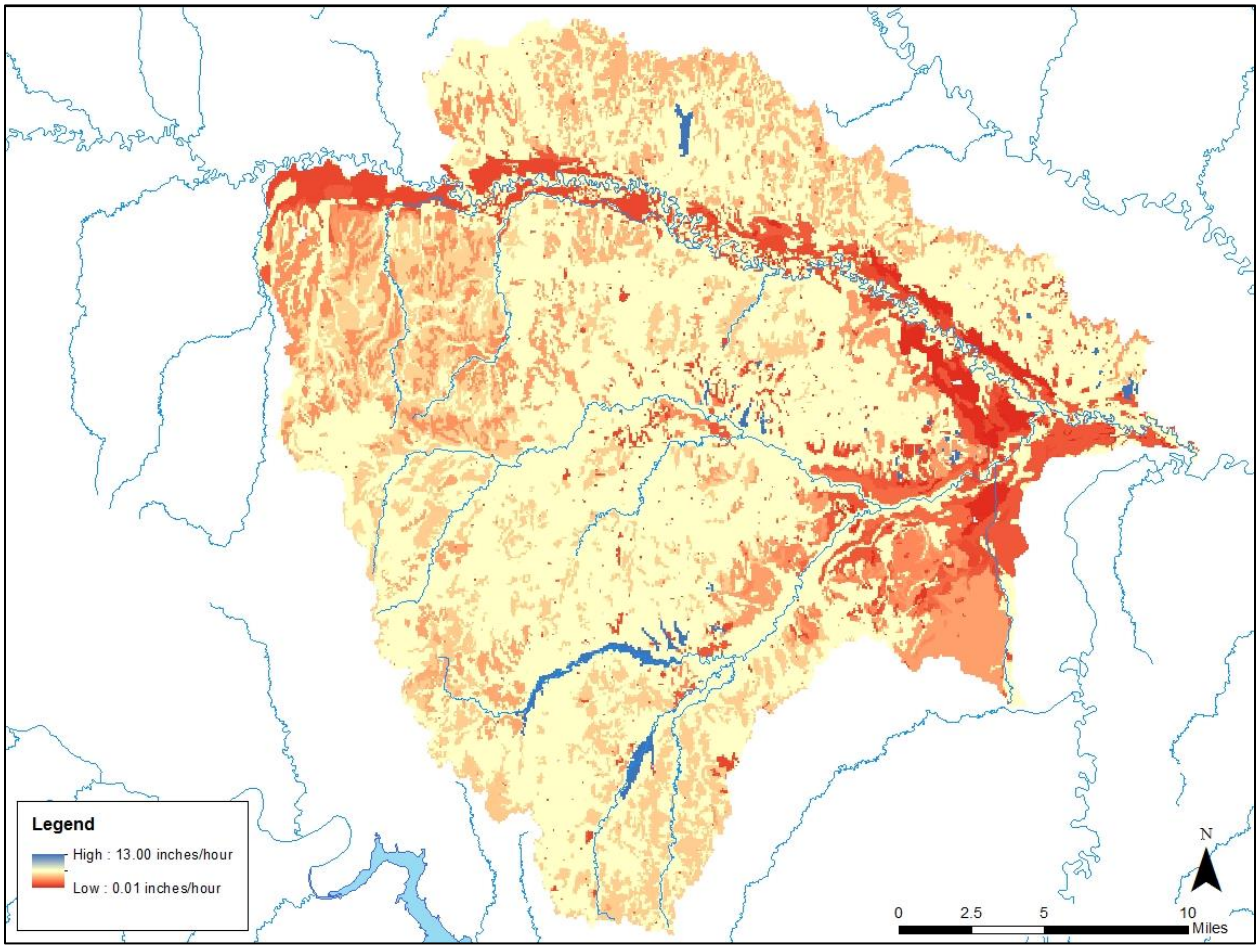
On-Site Waste Systems

The population of the Mulberry Creek and Saline River Watershed is predominantly rural. Urban populations are typically served by municipal sewer systems; however, rural populations may not be connected to the municipal sewer system. According to the U.S. Environmental Protection Agency's Spreadsheet Tool for Estimating Pollutant Load (STEPL), there are a total of 1,307 septic systems located in the Mulberry Creek and Saline River Watershed. Septic systems in the state of Kansas typically have an estimated 10-15% failure rate (Electric Power Research Institute provided by U.S. Environmental Protection Agency, 2017). Failing on-site septic systems have the potential to contribute to nutrient loading in the watershed. However, because of their small flows and the proclivity of phosphorus to adsorb to soil, failing on-site septic systems are considered a minor source of TP loading within the watershed and are not expected to significantly contribute to the TP impairment in the Mulberry Creek and Saline River Watershed.

Contributing Runoff

Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watershed's soil profiles become saturated, excess overland flow is produced. According to the NRCS STATSGO database, the Mulberry Creek and Saline River Watershed has a mean soil permeability of 1.29 inches/hour (**Figure 35**). Permeability in the watershed ranges from 0.01 to 13.00 inches/hour with approximately 66% of the watershed having a very low soil permeability of 1.29 inches/hour. According to a USGS open-file report, the threshold soil-permeability values are set at 3.43 inches/hour for very high, 2.86 inches/hour for high, 2.29 inches/hour for moderate, 1.71 inches/hour for low, 1.14 inches/hour for very low, and 0.57 inches/hour for extremely low soil-permeability (Juracek, 2000). Approximately 26.4% of the Mulberry Creek and Saline River Watershed is below the very low (1.14 inches/hour) threshold. Runoff is primarily generated as infiltration excess with rainfall intensities greater than soil permeability. As the watershed's soil profiles become saturated, excess overland flow is produced.

Figure 35. Map of Natural Resources Conservation Service State Soil Geographic Database soil permeability in the Mulberry Creek and Saline River Watershed.



Background Levels

Phosphorus is present over the landscape and in the soil profile. It is also present in terrestrial and aquatic biota. These biota can contribute to phosphorus loadings, particularly if they congregate to a density that exceeds the assimilative capacity of the land or water.

4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

The endpoints for this TMDL are based on the biological condition, pH, sestonic chlorophyll *a* and dissolved oxygen concentrations. All of these endpoints should improve to a level that provides full attainment of designated uses as phosphorus concentrations decrease in the Mulberry Creek and Saline River Watershed.

This TMDL is established as two phases to reduce phosphorus loadings and TP concentrations with periodic assessment of the biological condition in the creek. The Phase I TMDL TP milestone is set at a median concentration of 0.200 mg/L. Once TP concentrations in Mulberry Creek, as measured at SC640, and the Saline River, as measured at SC267, approach the Phase I

milestone of a median TP concentration of 0.200 mg/L, an intensive assessment of macroinvertebrate abundance and diversity will be performed to determine compliance with the narrative nutrient criteria. Presuming one or more of the numeric endpoints are not met at the end of Phase I, Phase II will commence with a TP milestone of a median concentration of 0.130 mg/L with additional reductions in loads and phosphorus concentrations accomplished through enhanced implementation of controls on sources in the watersheds.

Point Sources: The Phase I and Phase II WLA associated with the facilities discharging in the watershed are detailed in **Table 20**. All non-discharging lagoons have a Phase I and Phase II WLA of 0 lbs/day assigned. The two concrete plants have Phase I and Phase II WLAs of 0 lbs/day as they are not expected to contribute to the phosphorus loads in their watershed. The groundwater remediation site has Phase I and Phase II WLAs calculated at a nominal TP concentration of 0.2 mg/L and facility design flow, as it is expected to contribute only nominal phosphorus loads to the watershed. The WLAs for the four discharging lagoon systems treating domestic waste have been assigned Phase I and Phase II WLAs calculated using facility design flow and 2 mg/L TP, an effluent TP concentration commonly seen from Kansas lagoon systems. Additionally, all CAFO facilities are assigned a TP WLA of 0 lbs/day.

Table 20. Total phosphorus (TP) wasteload allocations for permitted facilities in the Mulberry Creek and Saline River Watershed.

Permitee	Kansas Permit Number	NPDES Permit Number	Facility Type	Design Flow (MGD)	TP Wasteload Allocation Concentration (mg/L)	TP Daily Wasteload Allocation (lbs/day)	TP Annual Wasteload Allocation (lbs/year)
Mulberry Creek (SC640)							
Ralph Luther Moblie Home Park	C-SA20-NO01	KSJ000178	Non-Discharging Lagoon	0	n/a	0	0.00
Rolling Hills Wildlife Adventure	C-SA20-NO03	KSJ000212	Non-Discharging Lagoon	0	n/a	0	0.00
Sundowner, INC. MHP	C-SA20-NO04	KSJ000133	Non-Discharging Lagoon	0	n/a	0	0.00
KOA of Salina	C-SH33-NO02	KSJ000544	Non-Discharging Lagoon	0	n/a	0	0.00
St. Francis Community & Family Services	C-SH49-NO01	KSJ000530	Non-Discharging Lagoon	0	n/a	0	0.00
Smoky Hill Weapons Range	F-SH33-NO01	KSJ000522	Federal Non-Discharging Lagoon	0	n/a	0	0.00
Bunge Groundwater Remediation	I-SA20-PO04	KS0100196	Industrial Groundwater Remediation	0.54	0.2	0.90	329.16
City of Brookville	M-SA02-OO01	KS0096831	Discharging Lagoon	0.0374	2	0.62	227.97
Sundowner West Meadows	M-SA20-OO01	KS0094161	Discharging Lagoon	0.011	2	0.18	67.05

Permitee	Kansas Permit Number	NPDES Permit Number	Facility Type	Design Flow (MGD)	TP Wasteload Allocation Concentration (mg/L)	TP Daily Wasteload Allocation (lbs/day)	TP Annual Wasteload Allocation (lbs/year)
Smoky Valley Concrete	I-SA20-PR03	KSG110077	Ready Mix Plant	*	0	0.00	0.00
Builders Choice Concrete- Salina	I-SA20-PR01	KSG110050	Ready Mix Plant	*	0	0.00	0.00
Total Phosphorus Total Wasteload Allocation in Mulberry Creek (SC640)						**1.70**	**624.18**
Saline River (SC267)							
City of Beverly	M-SA01-OO01	KS0095141	Discharging Lagoon	0.035	2	0.58	213.34
Tescott MWTP	M-SA17-OO01	KS0025691	Discharging Lagoon	0.0476	2	0.79	290.15
KDOT - Ottawa Co. Rest Area	M-SO27-NO01	KSJ000296	Non-Discharging Lagoon	n/a	n/a	0	0.00
Total Phosphorus Total Wasteload Allocation in the Saline River (SC267)						**1.37**	**503.49**
Total Phosphorus Total Reserve Wasteload Allocation						**3.00**	**1095.00**
Total Phosphorus Total Wasteload Allocation in Mulberry Creek (SC640) and the Saline River (SC267)						**6.07**	**2222.67**

Definitions: * - no data; n/a - not applicable

Reserve Wasteload Allocation

A reserve WLA of 3 lb/day is established to accommodate future development within the watershed. The reserve WLA may be apportioned throughout the Mulberry Creek and Saline River Watershed.

Municipal Separate Storm Sewer System

A portion of the City of Salina lies within the Mulberry Creek and Saline River watersheds. Hence, an MS4 load is allocated in each TMDL watershed. The MS4 loads were developed by assuming contributions would arise from the developed areas within the watershed. Thus, the MS4 WLA considers the proportion of developed land (open space and low, medium and high intensity) in the contributing areas of SC267 and SC640 of 0.42% and 3.56% respectively. Runoff volume during precipitation events in each of the contributing areas was estimated using Wiki Watershed: Model My Watershed with the precipitation value set at the model's default value of 2.5 cm. The Phase I runoff TP load for the SC267 and SC640 watersheds was calculated using their Phase I TP management milestones of 0.200 mg/L. These loads were then multiplied by 22% for SC267 and 16% for SC640, the percentage of time rain falls in the watershed (NOAA USC00144712 and NOAA USC00141057 1990-2017) with the resulting load multiplied by the percentage of developed land in the watersheds. Each watershed's load was then compared to the load allocation at 25% flow exceedance at the respective station showing the calculated runoff load to be 0.38% and 10% of the remaining load capacity each station during Phase I. The Phase II MS4 allocation was calculated the same way using the Phase II TP milestones of 0.130 mg/L at SC267 and SC640 resulting in runoff loads estimated at 0.38% and 11% at 25% flow exceedance at each station. During both phases, nominal MS4 allocations of 0.5 lb/day and 0.4 lb/day for Saline River and Mulberry Creek flows from 25 to 50 to percent flow exceedance and have been assigned to account for incidences of localized heavy rainfall

that may generate runoff conditions when the river is at or below median flow. MS4 permitees are expected to reduce phosphorus loading using best management practices to the maximum extent practicable.

Nonpoint Source Load Allocation: The load allocation (LA) is established to account for nonpoint sources of TP in the watershed. The LA is the remainder of the load capacity (LC) after all other allocations are accounted for. Loads from nonpoint source TP are assumed to be minimal during low flow conditions and grow proportionately as flow conditions increase, thereby accounting for increased runoff during precipitation events. As the Mulberry Creek and Saline River Watershed is influenced by nonpoint sources, the application of agricultural best management practices (BMPs) in riparian zones near cropland and livestock areas should be emphasized in order to abate and reduce nonpoint source TP loading in this watershed.

Figures 36 and 37 display current seasonal loading, the Phase I and II TMDL, and WLAs on Mulberry Creek (SC640) and the Saline River (SC267). Current condition, Phase I and II LC, WLA, and stormwater (MS4) allocations for each station can be seen in **Tables 21 and 22**. WLA were developed separately in Mulberry Creek and the Saline River, thus flow from Mulberry at terminus was subtracted from flow for the Saline River at terminus when calculating load capacities. The reserve WLA is also displayed in **Table 22**. Calculated LCs are based on TP management milestones and the estimated flow conditions in the river. Once TP loading in the Saline River at SC513 is accounted for, incremental loading for the Saline River TMDL watershed can be estimated by subtracting the upstream load from downstream loading capacity.

Figure 36. Phase I and II load capacity (TMDL) and wasteload allocation with current, seasonal loads displayed across the flow duration curve for Mulberry Creek near Salina(SC640).

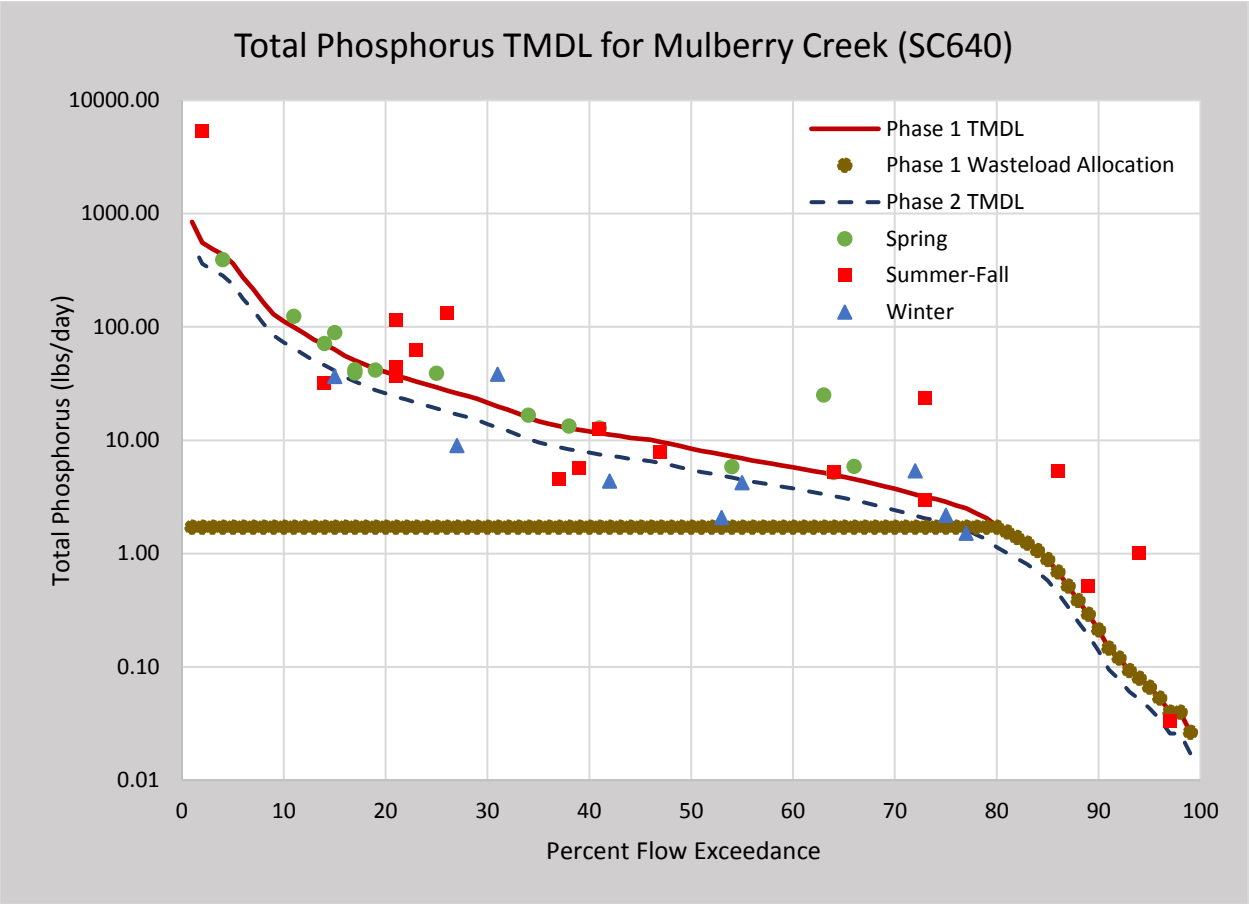


Table 21. Phase I and II load capacity (TMDL), wasteload, and MS4 stormwater allocation in Mulberry Creek near Salina (SC640).

Percent Flow Exceedance	Flow (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	MS4 Stormwater Allocations (lbs/day)	Load Allocation (lbs/day)
Phase I						
90%	0.20	0.23	0.21	0.21	0.00	0.00
75%	2.65	3.11	2.86	1.71	0.00	1.15
50%	7.81	9.15	8.43	1.71	0.5	6.22
25%	27.2	31.9	29.4	1.71	2.8	24.9
10%	103.9	121.7	112.2	1.71	11.0	99.4
Phase II						
90%	0.20	0.23	0.14	0.14	0.00	0.00
75%	2.65	3.11	1.86	1.71	0.00	0.15
50%	7.81	9.15	5.48	1.71	0.50	3.27
25%	27.2	31.9	19.09	1.71	1.91	15.47
10%	103.9	121.7	72.93	1.71	7.83	63.38

Figure 37. Phase I and II load capacity (TMDL) and wasteload allocation with current, seasonal loads displayed across the flow duration curve for the Saline River near New Cambria (SC267).

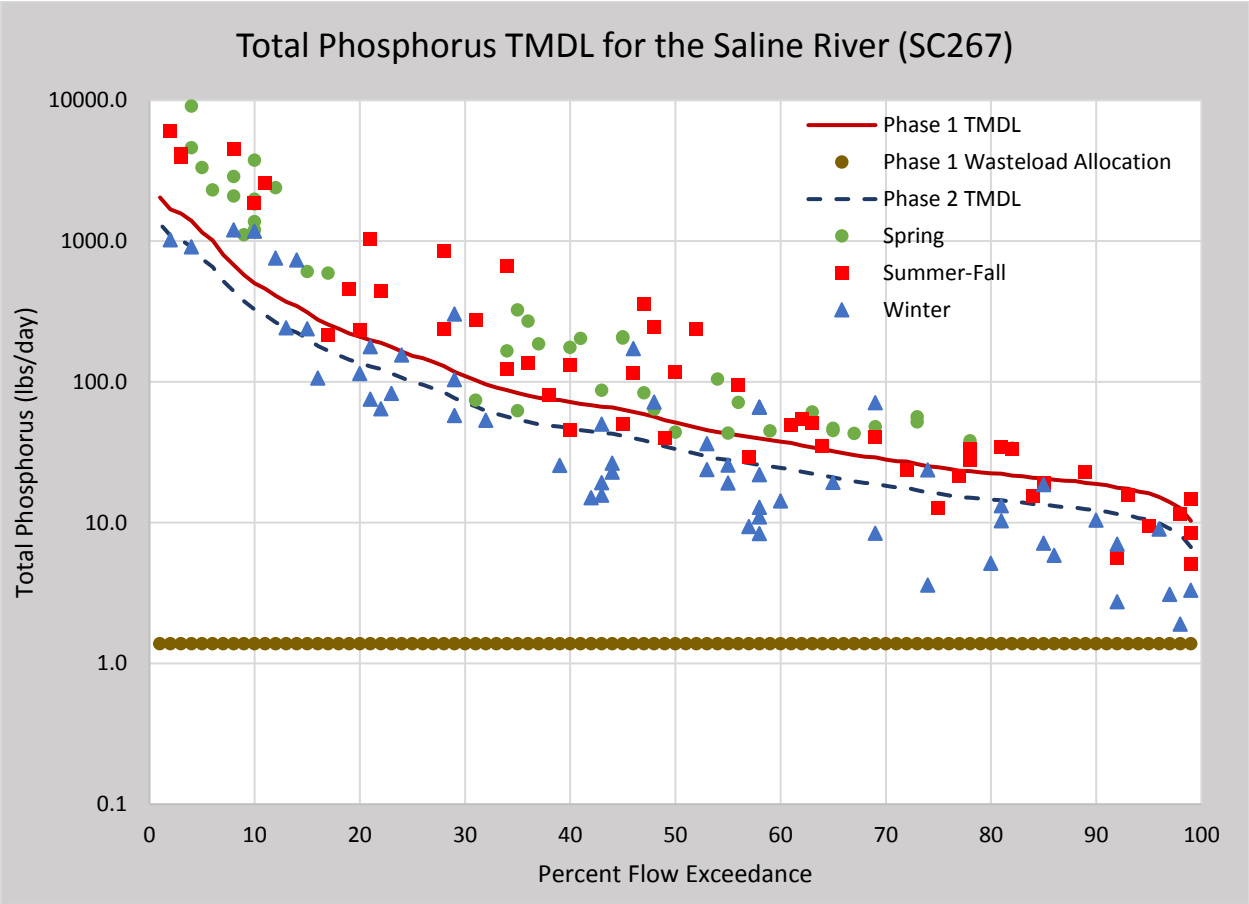


Table 22. Phase I and II load capacity (TMDL), wasteload, and MS4 stormwater allocation in the Saline River near New Cambria (SC267).

Percent Flow Exceedance	Flow (cfs)	Current Condition (lbs/day)	Load Capacity (lbs/day)	Wasteload Allocation (lbs/day)	MS4 Stormwater Allocations (lbs/day)	Reserve Wasteload Allocation (lbs/day)	Load Allocation (lbs/day)
Phase I							
90%	17.47	22.45	18.87	1.38	0.00	3.00	14.49
75%	22.90	29.44	24.74	1.38	0.00	3.00	20.36
50%	47.54	61.10	51.35	1.38	0.40	3.00	46.57
25%	141.8	182.24	153.14	1.38	0.57	3.00	148.20
10%	464.2	596.61	501.36	1.38	1.89	3.00	495.09
Phase II							
90%	17.47	22.45	12.26	1.38	0.00	3.00	7.88
75%	22.90	29.44	16.08	1.38	0.00	3.00	11.70
50%	47.54	61.10	33.38	1.38	0.30	3.00	28.70
25%	141.8	182.24	99.54	1.38	0.37	3.00	94.79
10%	464.2	596.61	325.88	1.38	1.23	3.00	320.27

Defined Margin of Safety: The margin of safety safeguards against the uncertainty in TP loading in the Mulberry Creek and Saline River Watershed. This TMDL uses conservative assumptions and relies on an implicit margin of safety. First, five endpoints are established by this TMDL to assess compliance with the narrative nutrient criteria. Second, the established endpoints must be maintained for three consecutive years before attainment of water quality standards can be claimed. Third, design flows are used for all point source WLAs, despite the current operation of most facilities under design flow and rarely discharge. Fourth, some facilities are assigned WLAs when it is likely that they contribute minimal nutrient loads

State Water Plan Implementation Priority: Early implementation of this TMDL will focus on riparian management to effectively reduce the phosphorus loading to the stream. Due to the need to reduce the high nutrient loads in the watershed, this TMDL will be **High Priority** for implementation.

Nutrient Reduction Framework Priority Ranking

This watershed lies within the Saline River Subbasin (HUC8 10260010), which includes tributaries to the top sixteen HUC8s targeted for state action to reduce nutrients.

Priority HUC12s

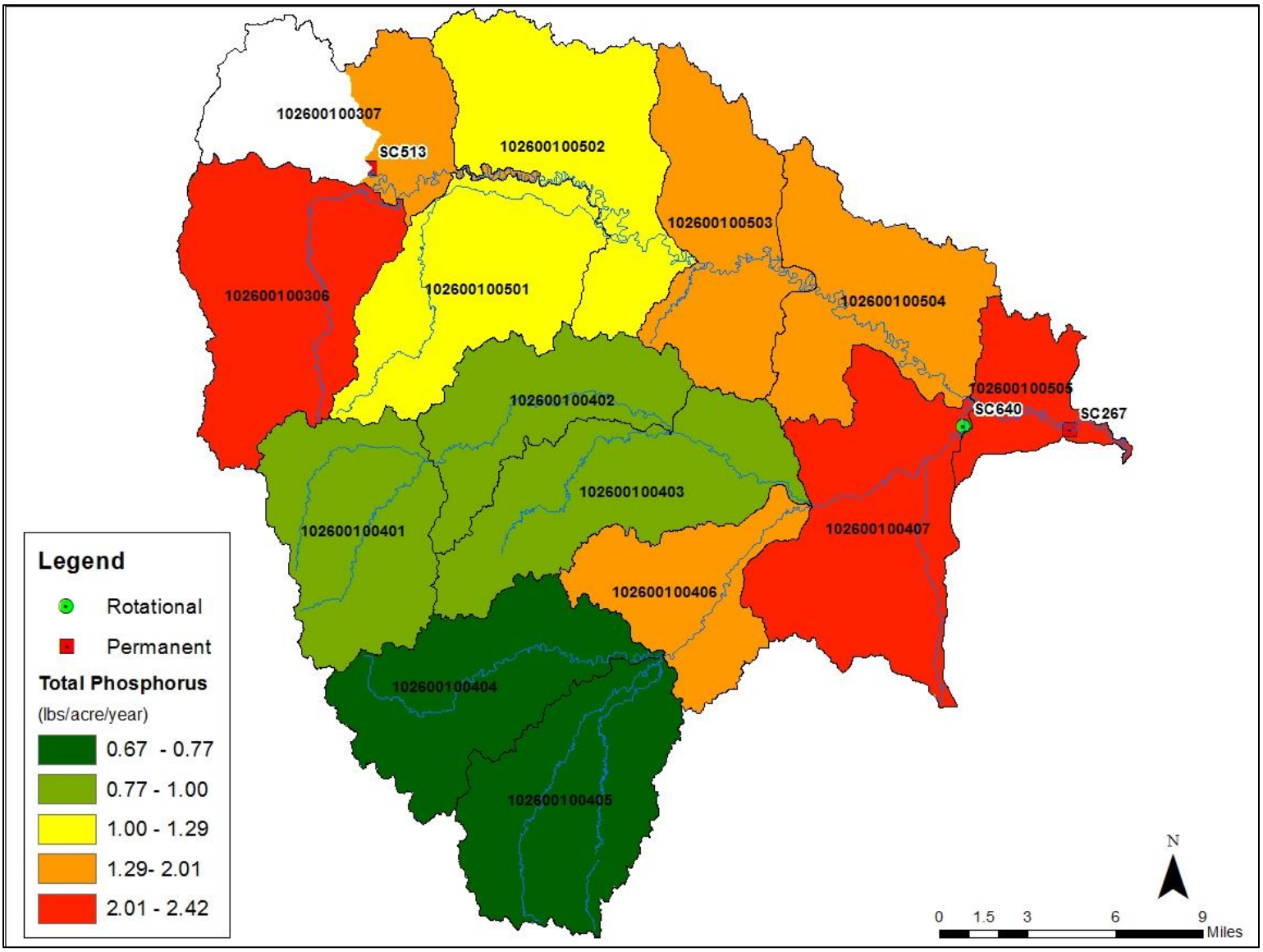
The Mulberry Creek and Saline River Watershed consists of 14 HUC12s (**Table 23**). According to STEPL the average amount of TP loading for the watershed is contributing 1.49 pounds per acre per year (lbs/acre/year). The priority HUC12s are 102600100306, 102600100407, and 102600100505 which all contribute more than 2 lbs/acre/year. Reductions in nonpoint sources will be the primary source of TP load reduction in this watershed. Implementation of BMPs in these priority HUC12s should reduce the main source of TP loading (**Figure 38**).

Table 23. Priority HUC12s by total phosphorus load and land use according to estimations from the Spreadsheet Tool for Estimating Pollutant Load in the Mud Creek (SC643) Watershed.

Watershed	Total (lbs/acre/year)
102600100407	2.42
102600100306	2.17
102600100505	2.01
102600100503	1.95
102600100406	1.82
102600100504	1.81
102600100307	1.68
102600100502	1.29
102600100501	1.27
102600100403	1.00
102600100402	0.99
102600100401	0.98
102600100404	0.77

Watershed	Total (lbs/acre/year)
102600100405	0.67
Average (lbs/acre/year)	**1.49**

Figure 38. Map of priority HUC12s by total phosphorus load according to estimations from the Spreadsheet Tool for Estimating Pollutant Load in the Mulberry Creek and Saline River Watershed.



5. IMPLEMENTATION

Desired Implementation Activities

1. Make operational changes in municipal wastewater treatment lagoons and implement alternative disposal such as irrigation.
2. Renew state and federal permits and inspect permitted facilities for permit compliance.
3. Improve riparian conditions along stream systems by installing grass and/or forest buffer strips along the streams and drainage channels in the watershed.
4. Implement and maintain conservation farming practices—including conservation tilling, contour farming, and no-till farming—in order to reduce runoff and cropland erosion of agricultural areas in the watershed.
5. Perform extensive soil testing to ensure excess phosphorus is not unnecessarily applied.
6. Ensure labeled application rates for chemical fertilizers are followed to reduce runoff.
7. Implement nutrient management plans and ensure that land-applied manure is properly managed to reduce runoff.
8. Establish pasture management practices, including proper stock density, to reduce soil erosion and storm runoff.
9. Ensure proper on-site waste system operations in proximity to main stream and tributary segments.

NPDES and State Permits – KDHE

1. Continue to monitor, ensure compliance, and confirm proper operation of wastewater facilities in this watershed.
2. Manage the WLA for the watershed to accommodate growth as needed.
3. Manure management plans, detailing proper land application rates and practices, will be implemented to prevent runoff of applied manure.
4. Inspect permitted livestock facilities to ensure compliance.
5. Inspect new permitted livestock facilities for integrity of applied pollution prevention technologies.
6. Apply pollution prevention technologies at livestock facilities.

Nonpoint Source Pollution Technical Assistance – KDHE

1. Support Section 319 implementation projects for nutrient management through reduction of phosphorus runoff from agricultural activities.
2. Provide technical assistance on practices to establish vegetative buffer strips.
3. Provide technical assistance on nutrient management for livestock facilities and practices which minimize impacts of small livestock operations in the watershed to reduce impacts to stream resources.

Water Resource Cost Share and Nonpoint Source Pollution Control Program – KDA-DOC

1. Apply conservation farming practices and/or erosion control structures, including no-till, terraces, contours, sediment control basins, and constructed wetlands.
2. Provide sediment control practices to minimize erosion and sediment transport from cropland and grassland in the watershed.
3. Install livestock waste management systems for manure storage.
4. Implement manure management plans.

Riparian Protection Program – KDA-DOC

1. Establish or re-establish natural riparian systems, including vegetative filter strips and streambank vegetation.
2. Develop riparian restoration projects along targeted stream segments, especially those areas with baseflow.
3. Promote wetland construction to reduce runoff and assimilate loadings.
4. Coordinate riparian management within the watershed and develop riparian restoration projects.

Buffer Initiative Program – KDA-DOC

1. Install grass buffer strips near streams.
2. Leverage Conservation Reserve Enhancement Programs to hold riparian land out of production.

Extension Outreach and Technical Assistance – Kansas State University

1. Educate agricultural producers on sediment, nutrient, and pasture management.
2. Provide technical assistance on buffer strip design and minimizing cropland runoff.
3. Encourage annual soil testing to determine capacity of field to hold phosphorus.
4. Educate residents, landowners, and watershed stakeholders about nonpoint source pollution.
5. Educate livestock producers on livestock waste management, land applied manure applications, and nutrient management planning.
6. Provide technical assistance on livestock waste management systems and nutrient management planning.

Timeframe for Implementation: There are no major dischargers in this watershed. However, rural runoff management should expand by 2020 to ensure nutrients are addressed. Pollutant reduction practices should be installed within the priority subwatersheds before 2024 with follow-up implementation over 2024-2028. Phase I of this TMDL should occur from 2020 to 2039. If biology in Mulberry Creek and the Saline River has not responded to Phase I reductions by 2039 then Phase II implementation should commence in 2040.

Targeted Participants: The primary participants for implementation of this TMDL are nonpoint sources of nutrients. Agricultural operations immediately adjacent to Mulberry Creek and the Saline River will be encouraged to implement appropriate practices to reduce phosphorus loads. Watershed coordinators, conservation district personnel, and county extension agents should coordinate to assess possible nutrient sources adjacent to streams. Implementation activities to address nonpoint sources should focus on those areas with the greatest potential to impact nutrient concentrations adjacent to the river.

Targeted activities to focus attention toward include:

1. Overused grazing land adjacent to the streams.
2. Sites where drainage runs through or adjacent to livestock areas.

3. Sites where livestock have full access to the stream as a primary water supply.
4. Poor riparian area and denuded riparian vegetation along the stream.
5. Unbufferred cropland adjacent to the stream.
6. Conservation compliance on highly erodible areas.
7. Total row crop acreage and gully locations.

Milestone for 2029: By 2029, advancement of necessary and appropriate measures to decrease the contribution of nonpoint sources of phosphorus loading in Mulberry Creek and the Saline River should be in progress. At that point in time, phosphorus data from the Mulberry Creek and the Saline River stream chemistry station SC267 should show indication of declining concentrations relative to the pre-2019 data, particularly during low and normal flow conditions.

Delivery Agents: The primary delivery agent for program participation will be KDHE.

Reasonable Assurances

Authorities*:* The following authorities may be used to direct activities in the watershed to reduce pollution:

1. K.S.A. 65-164 and 165 empowers the Secretary of KDHE to regulate the discharge of sewage into the waters of the state.
2. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.
3. K.S.A. 2002 Supp. 82a-2001 identifies the classes of recreation use and defines impairment for streams.
4. K.A.R. 28-16-69 through 71 implements water quality protection by KDHE through the establishment and administration of critical water quality management areas on a watershed basis.
5. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation, and management of soil and water resources in the state, including riparian areas.
6. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.
7. K.S.A. 82a-901, et. seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.
8. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*.
9. The *Kansas Water Plan* provides the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

Funding: The State Water Plan annually generates $12-13 million and is the primary funding mechanism for implementing water quality protection and pollution reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watershed and water resources by priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are located within a **High Priority** area and should receive support for pollution abatement practices that lower the loading of sediment and nutrients.

Effectiveness: Nutrient control has been proven effective through conservation tillage, contour farming and use of grass waterways and buffer strips. In addition, the proper implementation of comprehensive livestock waste management plans has proven effective at reducing nutrient runoff associated with livestock facilities.

6. MONITORING

Future stream chemistry sampling is scheduled to occur quarterly on an annual basis at SC267 in the Saline River and at SC640 in Mulberry Creek. Monitoring will include summer sestonic chlorophyll *a* sampling and dissolved oxygen and pH levels will be assessed for indications of heightened primary productivity. Monitoring of TP should occur in Dry Creek and Mulberry Creek in the SC640 watershed and in the Saline River in the SC267 watershed as a condition of the City of Salina's MS4 permit.

Ongoing macroinvertebrate sampling will be conducted in the Saline River at SC267 with occasional biological sampling of Mulberry Creek during Phase I implementation over the 2020-2029 time period. As the Phase I TP milestone of 0.200 mg/L TP is approached in Mulberry Creek and the Saline River, macroinvertebrate sampling will be conducted and examined for signs of favorable responses in the aquatic community. Should the biological community fail to respond, Phase II implementation will commence with a TP milestone of 0.130 mg/L in both Mulberry Creek (SC640) and the Saline River (SC267).

Once the biological endpoints are achieved, the conditions described by the narrative nutrient criteria will be viewed as attained and the Saline River (SC267) and Mulberry Creek (SC640) will be considered for delisting. Once the water quality standards are attained, the adjusted ambient phosphorus concentrations will be the basis for establishing numeric phosphorus criteria through the triennial water quality standards process.

7. FEEDBACK

Public Notice

An active website is established at http://www.kdheks.gov/tmdl/planning_mgmt.htm to convey information to the public on the general establishment of TMDLs and to provide specific

TMDLs by river basin. This TMDL was posted to the Smoky Hill-Saline River Basin on this site on November 29, 2018 for public review.

Public Hearing

A public hearing on this TMDL was held on December 14, 2018 in Salina, Kansas to receive public comments. No comments were received.

Milestone Evaluation

In 2029, evaluation will be made as to the degree of implementation that has occurred within the watershed. Subsequent decisions will be made through consultation with local stakeholders and regarding implementation of nonpoint source reduction strategies and development of additional implementation strategies for the watershed.

Consideration for 303(d) Delisting

Mulberry Creek and the Saline River segments covered by this TMDL will be evaluated for delisting under Section 303(d) based on the monitoring data from 2018 to 2029. Therefore, the decision for delisting will ensue in the preparation for the 2030 Section 303(d) list. Should modifications be made to the applicable water quality criteria during the implementation period, consideration for delisting, desired endpoints of this TMDL, and implementation activities may be adjusted accordingly.

Incorporation into the TMDL Vision Process, Water Quality Management Plan, and the Kansas Water Planning Process

Under the current version of the Kansas TMDL Vision Process, the next anticipated revision of this TMDL will be after 2024. At that time, the revision will emphasize implementation of activities and this TMDL will be incorporated into future plans. Recommendations for this TMDL will be considered in the *Kansas Water Plan* implementation decisions under the State Water Planning Process for fiscal years 2019 - 2029.

Developed: *April 1st, 2019*

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